

AN INVESTIGATION OF STRESSES IN A SHEAR
PANEL WITH ACCESS HOLE BY THE USE OF
STRESSCOAT

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A THESIS

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Preface

Meaning of Symbols Used

- b = Distance between bolt center lines, inches.
- C_e = Experimental Stress Concentration Factor.
- C_t = Theoretical Stress Concentration Factor.
- d = Diameter of access hole, inches.
- ϵ_t = Experimental tensile strain, inches per inch.
- E = Effective modulus of elasticity, pounds per square inch.
- f_{s1} = Experimental maximum shear stress at access hole, pounds per square inch.
- f_{s2} = Average maximum shear stress in panel allowing for access hole, pounds per square inch.
- f_{s3} = Average maximum shear stress for solid panel, pounds per square inch.
- P = Applied tensile load, pounds.
- t = Nominal panel thickness, inches.

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SUMMARY

Stress distribution patterns and stress concentration factors were determined for 24S-T aluminum-alloy panels in pure shear with varying diameter access holes by the Stresscoat method. Panels with thicknesses of 0.040 inch and 0.064 inch were tested. It was found that:

1. Stresscoat provides a simple means of visually checking stress patterns in shear panels.
2. Usually one test will show the location, direction, and approximate magnitude of maximum strain.
3. Maximum shear stress occurred at an angle of 45 degrees to the direction of the diagonal-tension axis of the panel.
4. Experimental stress concentration curves indicate a variation of stress concentration with panel thickness.
5. When shear panels with large diameter access holes are highly stressed the flanges carry a large portion of the shear load.

INTRODUCTION

In aircraft structures, access holes are frequently made in shear panels to permit the installation of controls, plumbing, and to facilitate construction and inspection. Previous work by Kuhn and Levin¹ consisted of determining the stress concentration at static rupture, and the deformation characteristics of shear panels with 1 1/2-inch holes. Ruffner and Schmidt² investigated the effect of cut-outs in shear resistant webs by the photoelastic method, which is limited to the unbuckled range.

The purpose of this investigation was to determine the stress distribution patterns, and stress concentration factors induced in a shear panel by various size access holes. The Stresscoat³ method was used as it gives a good overall picture of the stress pattern, and the location, direction, and approximate magnitude of maximum strain up to the yield point. This permits studies for shear loads in

¹ Kuhn, Paul and Levin, Ross L.: "Tests of 10-inch Aluminum-Alloy Shear Panels with 1 1/2-inch Holes." Wartime Report No. L-500, N.A.C.A., June, 1943.

² Ruffner, Benjamin F. and Schmidt, Calvin L.: "Stresses at Cut-Outs in Shear Resistant Webs as Determined by the Photoelastic Method." Technical Note No. 984, N.A.C.A., October, 1945.

³ Anonymous: "Operating Instructions for Stresscoat." Manual furnished by the Magnaflux Corporation to purchasers of Stresscoat Equipment.

excess of the buckling values, provided the combined stresses do not exceed the yield strength over any considerable portion of the panel.

TEST EQUIPMENT

Specimens.- The specimens consisted of panels of 24S-T aluminum-alloy; two thicknesses were used, 0.040 inch and 0.064 inch.

Test Jig.- The square-picture-frame test jig, (Figure 2), consisted of flanges made of X-4130 steel bars $1/4 \times 1 \times 11$ inches. These were bolted to both sides of the panel with $1/4$ diameter steel bolts. The bolts spacing was $3/4$ inches along the span of the flange. The distance between center lines of the bolts was 10 inches; the clear width of the panel was 9 inches. The test jig was so designed that when a tensile load was applied, at the opposite diagonal corners of the jig, the panel was subjected to pure shear. A link arrangement was used, in applying the load, to eliminate the possibility of inducing bending moments.

Stresscoat.- Stresscoat is the trade name given to a series of 12 brittle lacquers manufactured by the Magnaflux Corporation. These brittle lacquers, when dried on a specimen, fracture at right angles to the direction of principle stress. Their cracking sensitivity is fairly independent of the thickness of coating between 0.003 and 0.006 inches. The main disadvantage is their extreme sensitivity to temperature and

humidity conditions. This can be overcome by selecting the proper coating for the temperature and humidity conditions of the laboratory. Accuracy of approximately plus or minus 10 per cent can be achieved with careful technique.

Testing Machine.- The Universal Testing Machine at the Daniel Guggenheim School of Aeronautics at the Georgia School of Technology was used in applying the tensile load to the shear panel.

Photography.- The photographic equipment used was located in the Photography Laboratory at the State Engineering Experiment Station at the Georgia School of Technology. The camera was a Speed Graphic, with a 4 x 5 inch ground glass focusing plate. The film was 4 x 5 inch Contrast Process. Two Number 2 Photoflood bulbs, in 12 inch diameter reflectors, provided the light source. The Photoflood lights were placed at angles of 45 degrees to the panel. Exposure time was f-32 at 1/2 second. In developing the film D-11 developer was used. The film was left in this solution for 8 minutes.

TEST PROCEDURE

The 0.064 inch thick panel was tested first, and then the 0.040 inch thick panel. The panels were tested first as solid sheets, and then with access hole of 1, 2, 3, 4, 5, and 7 inches in diameter.

The panel was bolted between the flanges of the square-picture-frame test jig. It was cleaned thoroughly

with aluminum cleaner and then with thinners, ST-1, and ST-2. A thin undercoating of aluminum-pigmented lacquer, ST-840, was applied to both sides of the test panel, and to three calibration bars. Fifteen minutes were allowed for this undercoating to dry, before applying the strain-indicating coating. The proper coating was selected by use of the sling psychrometer, to obtain the wet and dry bulb temperatures, and then applying this data to the coating selection chart. The coating selected was then sprayed upon both sides of the test panel and calibration bars. In spraying the panel and calibration bars attempt was made to have the coating thickness approximately 0.005 inches. To build up the required thickness, six to eight passes of the spray gun were required. The panel and calibration bars were then allowed to dry over-night. During drying, the panel and calibration bars were kept together and away from drafts. This was done to have them subjected to the same temperature and humidity conditions.

The test jig was then placed in the Universal Testing Machine, and a tensile load was applied in a steady continuous manner until the first cracks appeared in the coating. Contour lines were drawn around the stress pattern, and marked with the applied tensile load value. The load was then removed, and was left off twice as long as it had been applied. This was to correct for creep in the coating. Then the load was increased 10 to 30 per cent beyond the previous load, and

when a new stress pattern appeared in the coating it was contoured, marked with the applied tensile load value, and the load removed. This method of loading, contouring, and recording the load value was repeated until the panel was completely stress patterned for applied loads below the permanent buckling load.

At the time of testing the panel, the calibration bars were placed in the calibrator and loaded; then placed in the strain scale and the strain recorded. One bar was tested before starting the tests on the panel, and the other two between load changes on the panel to obtain an average of the indicated strain.

When the panel was completely stress patterned, it was removed from the testing machine and dye-etched with red-dye-etchant, ST-1300. The dye-etchant was applied with a soft brush, on both sides of the panel, and allowed to dry for approximately one and one-half minutes. Another coat was then brushed on and removed immediately with etchant emulsifier, ST-1301. The red-dye-etchant was used to bring out all patterns which were formed during testing, and to dye them a permanent red. This red-dye-etchant also increased the visibility of the patterns and made them easier to study and photograph. The test jig was then taken to the Photography Laboratory where both sides of the panel were photographed.

The panel was then scraped of the Stresscoating and a hole was drilled or enlarged to the next size. This was done with the use of fly-cutters. The hole was then sandpapered smooth and the specimen prepared as listed above for the next test.

When all of the tests on each panel had been made, with the use of Stresscoat, it was tested to rupture. No Stresscoat was used in this test as the panel was tested beyond its yield point.

DISCUSSION

When wing spars made up of shear panels are tested to destruction, quite often failure will occur first at points which were not considered critical. These sections are often subjected to various induced stresses for which the existing design formulas did not allow. Stresscoat will indicate these points before the spar has become permanently damaged. The designer can then correct the design at these locations of high stress concentration, and proceed with the test. This will eliminate the time and expense of re-testing another spar in order to meet the design requirements.

The buckling theory of thin plates has been given by Timoshenko⁴ and will not be discussed in this thesis.

⁴ Timoshenko, S.: Theory of Elastic Stability. Pages 325-418, McGraw-Hill Book Co., Inc., First Edition, 1936.

Mills⁵, in his study of stresses in the web of an incompletely developed tension field beam, discussed in detail the combined stresses in the web upon buckling.

The results of tests on shear panels with various diameter access holes are presented in the appendix as a series of photographs, Figures 2 through 33. They show the stress distribution patterns at various applied load values. The number of the Stresscoat used and its sensitivity are given in the captions.

Figures 4 and 5 show the stress distribution patterns for the front and rear sides of the solid 0.040 inch thick panel. Stresscoat Number ST-1208 was used and it had a cracking sensitivity of 0.00092 inches per inch. When the applied load had reached 1550 pounds, cracks appeared in the coating. On the front side of the panel, Figure 4, the cracks were perpendicular to the diagonal-tension axis of the panel. The contour of these cracks was in the shape of an ellipse with major axis along the diagonal-tension axis. These cracks were caused by the combination of diagonal-tensile and secondary bending stresses. As seen from the front, a convex buckle was formed. This is indicated by the tension cracks.

⁵Mills, F. C.: "The Application of Stresscoat in the Study of Stresses in the Web of an Incompletely Developed Tension Field Beam." Thesis submitted for Master's Degree in Aeronautical Engineering, Georgia School of Technology, 1947.

When the applied load value reached 4500 pounds the stress pattern had spread outward, but its contour was still in the shape of an ellipse. The small cracks parallel to the direction of the diagonal-tension axis were due to the high secondary bending stress at the crest of the buckle. This stress was sufficient to crack the coating as it was large enough to off-set the diagonal-tensile and compressive stresses. Cracks also appeared at the sides of the flanges. These were due to the flange restraints which forced the panel back into its original plane section at those points.

On the rear side of the panel, Figure 5, the first cracks appeared at the applied load value of 1550 pounds. These cracks were in the corners of the diagonal-tension axis. This indicates that there was some secondary bending in the corners, which was also due to flange restraints.

When the applied load value had reached 4500 pounds cracks appeared in the panel perpendicular to the diagonal tension axis. The contour of these patterns was in the shape of an ellipse inside of an ellipse. This indicates that the main buckle was concave, as observed from the rear side of the panel, and had its major axis along the diagonal-tension axis. This was evident from the lack of stress patterns inside the small ellipse. Convex buckles were formed on each side of the main concave buckle as indicated by the tension cracks.

Upon sudden release of the applied load cracks appeared in two places parallel to the direction of the

diagonal-tension axis of the panel. The contour of these cracks are shown by the dotted lines. The explanation of these cracks is that Stresscoat creeps under load, and since the loading cycle took an appreciable time the portion of the coating under compression readjusted itself to the applied load. When the load was released the coating cracked in tension, since the buckle disappeared when the panel resumed its original plane section.

Figures 8 and 9 show the stress distribution patterns for the front and rear sides of the 0.040 inch thick panel with a 2 inch diameter access hole. Stresscoat Number ST-1208 was used, and it had a cracking sensitivity of 0.00077 inches per inch. Cracks first appeared at the edges of the hole whose tangents were parallel to the diagonal-tension axis, when the applied load had reached 900 pounds. These cracks appeared almost simultaneously on both sides of the panel and at both hole edges, indicating uniform tensile strain. As the load was increased to 1000 pounds the cracks spread outward, and were perpendicular to the direction of the diagonal-tension axis.

The appearance of cracks on the other two sides of the hole were observed, Figure 8, at the same load value of 1000 pounds. These cracks were parallel to the diagonal-tension axis and as they extended further away from the edge of the hole their direction was changed 90 degrees. The explanation of this is that at the edge of the hole the

diagonal-tensile stress was zero, and the secondary bending stress caused cracks to form. As these cracks extended away from the hole edge, in the direction of diagonal-tension axis, the diagonal-tensile stress became predominant and the cracks were then due to the tensile stress which was 90 degrees to the secondary bending stress.

When the applied load was raised to 1600 pounds the contour of the stress distribution pattern was in the shape of an ellipse. As the cracks were due to the tensile load the buckle formed, as viewed from the front, was convex.

It is interesting to note that the contour of the stress pattern indicated that the principal maximum stress is in a direction tangent to the hole edge around its entire circumference, which is in accordance with theory. Obviously the minimum principal stress is zero.

On the rear side of the panel, Figure 9, stress distribution patterns for the 1600 pound load appeared to take the form of a cloverleaf. This indicated that convex buckles were being formed on opposite sides of the access hole, and were parallel to the concave buckle which was formed in the center of the panel parallel to the diagonal-tension axis. When the load was released compression strains appeared at the edges of the hole and extended towards the diagonal-tension corners. Their contours are indicated by the dotted lines.

Figure 18 shows the 0.040 inch thick panel with a

7 inch diameter access hole at rupture. No Stresscoat was used in this test as the panel was tested beyond its yield point. At an applied load of 6500 pounds rupture occurred at the edge of the hole, and moved outward to the lower right hand corner. The direction of this rupture was perpendicular to the diagonal-tension axis of the panel, indicating that failure was due to concentrated diagonal-tensile stresses at the hole edge.

Figure 33 shows the 0.064 inch thick panel with a 7 inch diameter access hole at rupture. Failure occurred at an applied tensile load of 11,100 pounds. The rupture occurred in the lower left hand corner. The crack was in the direction of the diagonal-tension axis, indicating that high secondary bending stresses in the corner, superimposed on the diagonal-tensile stress, were the cause of failure. Considerable yielding was noticed in the sides of the panel around the hole. The high secondary bending stresses caused permanent set of the main buckle.

Theoretical stress concentration factors⁶ were based upon the inverse ratio of the net cross-sectional area to the area of the solid panel. This can also be expressed as the ratio of average maximum shear stress in panel allowing for

⁶Williams, George K.: Advanced Aircraft Structures. Unpublished Lecture Notes from Aeronautical Engineering Course Entitled, "Advanced Aircraft Structures." Georgia School of Technology, Atlanta, Georgia.

access hole to the average maximum shear stress in solid panel. Then:

$$C_t = \frac{f_{s2}}{f_{s3}}$$

Where:

$$f_{s2} = \frac{0.707 P}{(b - d)t}$$

$$f_{s3} = \frac{0.707 P}{bt}$$

The principal axes are parallel to and perpendicular to the edge of the hole. The maximum shear stress at the edge of the hole is then equal to one-half of the maximum principal stress since the minimum principal stress is zero. The experimental stress concentration factors were then determined by the ratio:

$$C_e = \frac{f_{s1}}{f_{s3}}$$

Where:

$$f_{s1} = \frac{(\epsilon_t)(E)}{2}$$

Figure 1 shows the stress concentration factors plotted against the ratio of access hole diameter to the distance between bolt center lines. Experimental stress concentration curves indicate a variation of stress concentration with panel thickness. Further tests may indicate that this is not the case. At the time of this investigation it was intended to check these values by the use of strain gages, but the equipment was not available in time to make these tests.

Although it was assumed that the flanges did not carry any appreciable portion of the shear load, it is evident that they were carrying some. Figure 18 shows that when the 0.040 inch thick panel with a 7 inch diameter access hole was tested to rupture, the flanges were carrying a considerable portion of the shear load. This is evident from the amount of their bending.

Theoretically when the diameter of the access hole approaches the distance between bolt center lines, the stress concentration factor approaches infinity. The experimental stress concentration factor would not approach infinity when the diameter of the access hole approached the distance between bolt center lines. Instead, it would approach a finite value, which would be determined by the shear strength and bending stiffness of the flanges.

CONCLUSIONS

Stresscoat is very well adapted to shear panels with access holes. It gives a good overall picture of the entire stress distribution pattern, and the location, direction, and approximate magnitude of maximum strain at the edge of the access hole. From Stresscoat data strain gage measurements can readily be made to determine more accurately the stresses throughout the panel. From the foregoing discussion of the photographs and the stress concentration factors the

following conclusions can be drawn:

1. Stresscoat provides a simple means of visually checking stress distribution patterns in shear panels.
2. Usually one test will show the location, direction, and approximate magnitude of maximum strain.
3. Quantitative results can be obtained in a laboratory where the temperature and humidity conditions can be kept constant or within very close limits of variation.
4. Maximum shear stress occurred at an angle of 45 degrees to the direction of the diagonal-tension axis of the panel.
5. Experimental stress concentration curves indicate a variation of stress concentration with panel thickness. Further tests by the use of strain gages may indicate that this is not the case.
6. When shear panels with large diameter access holes are highly stressed the flanges carry a large portion of the shear load.

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APPENDIX

SAMPLE CALCULATIONS

Determination of experimental and average maximum shear stress and stress concentration factors in a 0.040 inch thick shear panel with 2 inch diameter access hole.

Experimental Maximum Shear Stress at Hole:

$$f_{s1} = \frac{(\epsilon_t)(E)}{2}$$

Where:

$$\epsilon_t = 0.00077 \text{ in./in.}$$

$$E = 10.2 \times 10^6 \text{ lbs./in.}^2$$

$$f_{s1} = \frac{(0.00077)(10.2 \times 10^6)}{2}$$

$$f_{s1} = 3927 \text{ lbs./in.}^2 \quad \longleftarrow$$

Average Maximum Shear Stress in Panel Allowing for Access Hole:

$$f_{s2} = \frac{0.707 P}{(b - d)t}$$

Where:

$$P = 900 \text{ lbs.}$$

$$b = 10 \text{ in.}$$

$$d = 2 \text{ in.}$$

$$t = 0.040 \text{ in.}$$

$$f_{s2} = \frac{(0.707)(900)}{(10 - 2)(0.040)}$$

$$f_{s2} = 1988 \text{ lbs./in.}^2 \quad \leftarrow$$

Average Maximum Shear Stress in Solid Panel:

$$f_{s3} = \frac{0.707 P}{bt}$$

Where:

$$P = 900 \text{ lbs.}$$

$$b = 10 \text{ in.}$$

$$t = 0.040 \text{ in.}$$

$$f_{s3} = \frac{(0.707)(900)}{(10)(0.040)}$$

$$f_{s3} = 1591 \text{ lbs./in.}^2 \quad \leftarrow$$

Experimental Stress Concentration Factor:

$$C_e = \frac{f_{s1}}{f_{s2}}$$

Where:

$$f_{s1} = 3927 \text{ lbs./in.}^2$$

$$f_{s3} = 1591 \text{ lbs./in.}^2$$

$$C_e = \frac{3927}{1591} = 2.47 \quad \leftarrow$$

Theoretical Stress Concentration Factor:

$$C_t = \frac{f_{s2}}{f_{s3}}$$

Where:

$$f_{s2} = 1988 \text{ lbs./in.}^2$$

$$f_{s3} = 1591 \text{ lbs./in.}^2$$

$$C_t = \frac{1988}{1591} = 1.25$$



Data for 0.040 inch thick Shear Panel

[illegible]

Data for 0.064 inch thick Shear Panel

d	b	$\frac{d}{b}$	t	P	E_t	E	f _{s1}	f _{s2}	f _{s3}	C _e	C _t
0	10	0.0	0.064	5000	0.00093	10.2 x 10 ⁶	-----	5523	5523	-----	1.00
1	10	0.1	0.064	3500	0.00170	10.2 x 10 ⁶	8670	4296	3866	2.24	1.11
2	10	0.2	0.064	2500	0.00125	10.2 x 10 ⁶	6375	3452	2761	2.31	1.25
3	10	0.3	0.064	2100	0.00110	10.2 x 10 ⁶	5610	3314	2320	2.42	1.43
4	10	0.4	0.064	2000	0.00115	10.2 x 10 ⁶	5865	3682	2209	2.66	1.67
5	10	0.5	0.064	1500	0.00105	10.2 x 10 ⁶	5355	3314	1657	3.23	2.00
7	10	0.7	0.064	900	0.00110	10.2 x 10 ⁶	5610	3314	994	5.64	3.33
7	10	0.7	0.064	11100	Rupture						

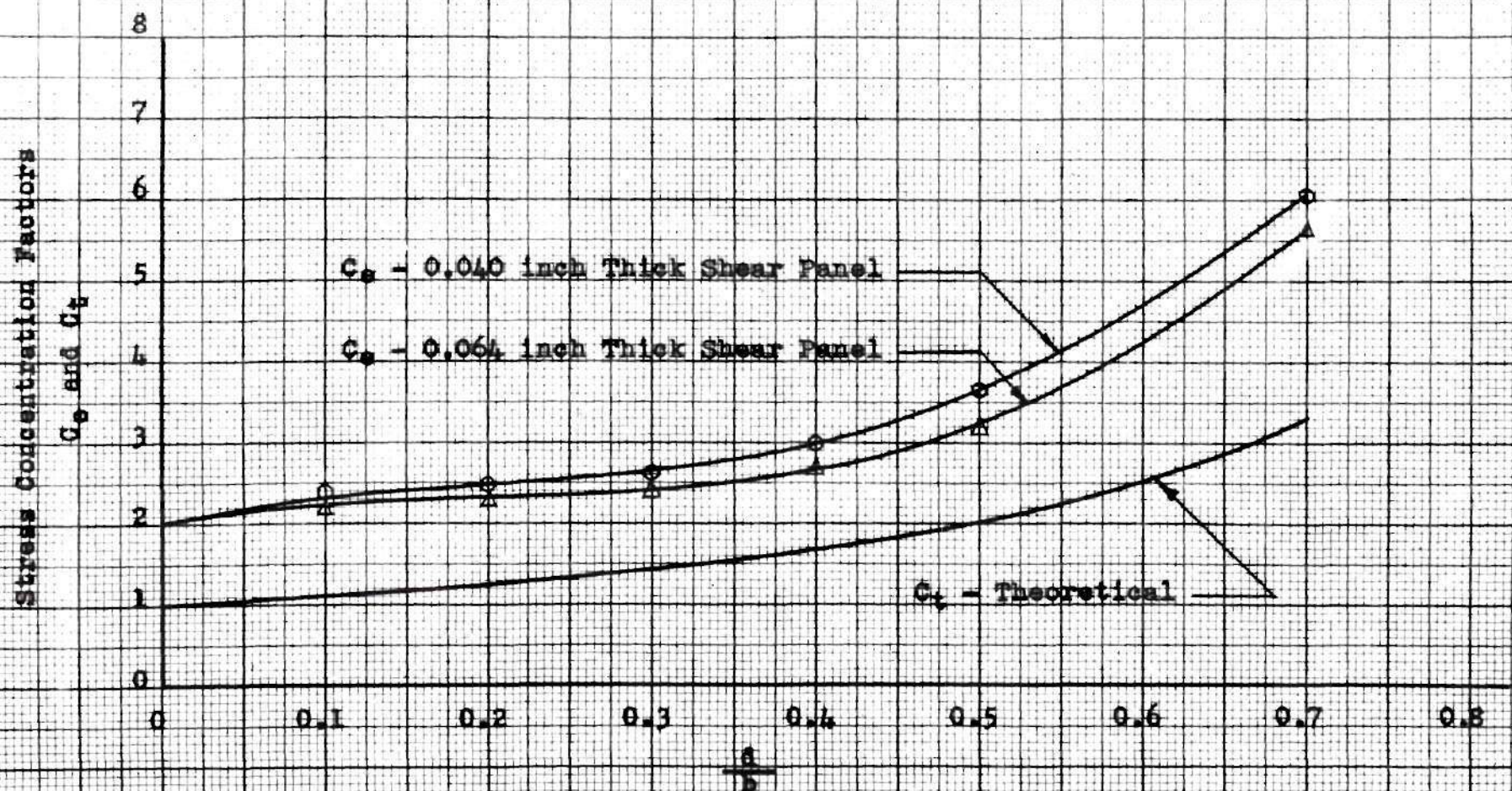


Figure 1. Experimental and Theoretical Stress Concentration Factors

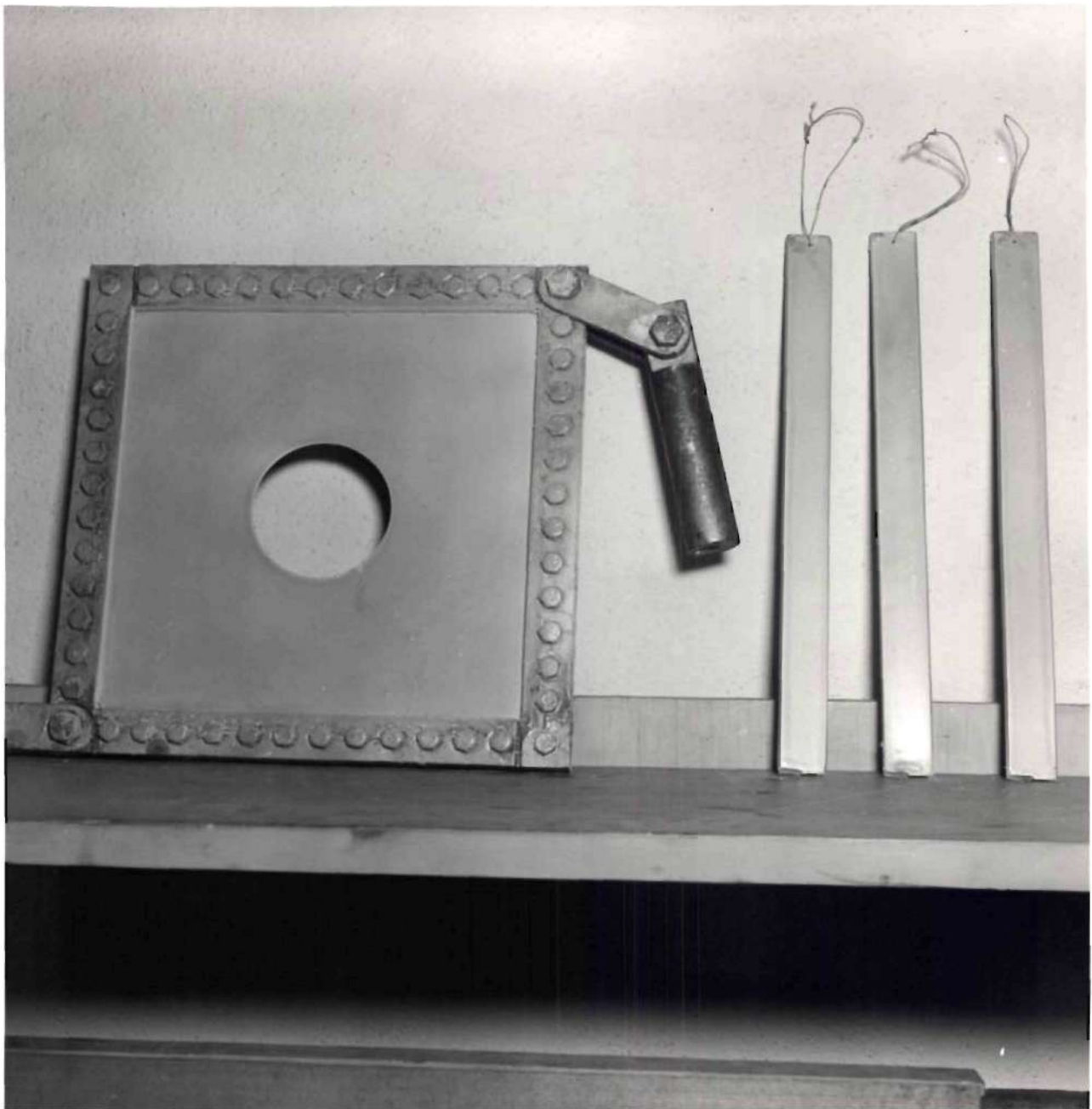


Figure 2. Shear panel and calibration bars
Stresscoated and drying.

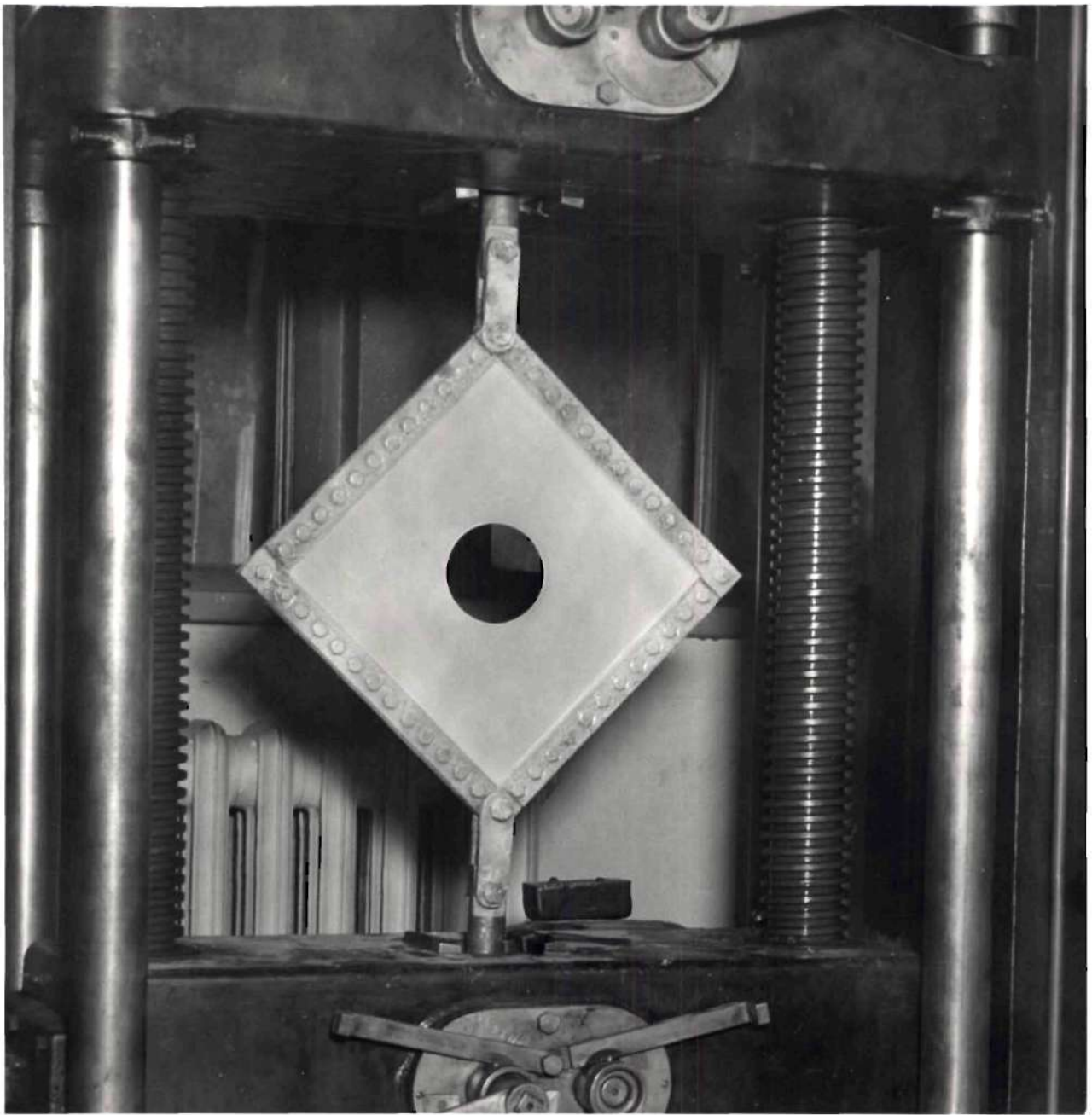


Figure 3. Shear panel in testing machine.

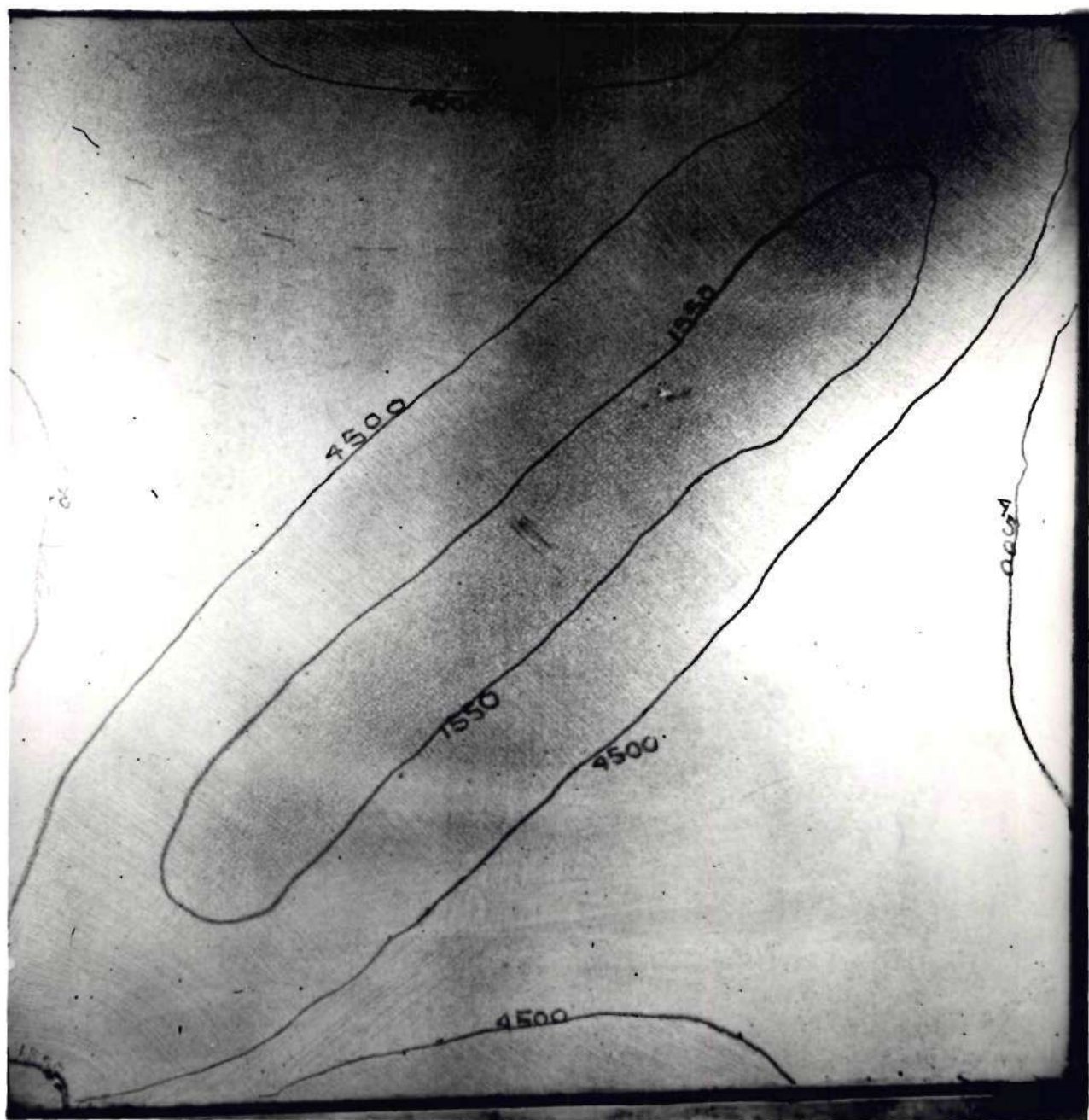


Figure 4. Stress pattern, 0.040 panel, front.
Sensitivity 0.00092 in./in.
Stresscoat No. ST-1208.

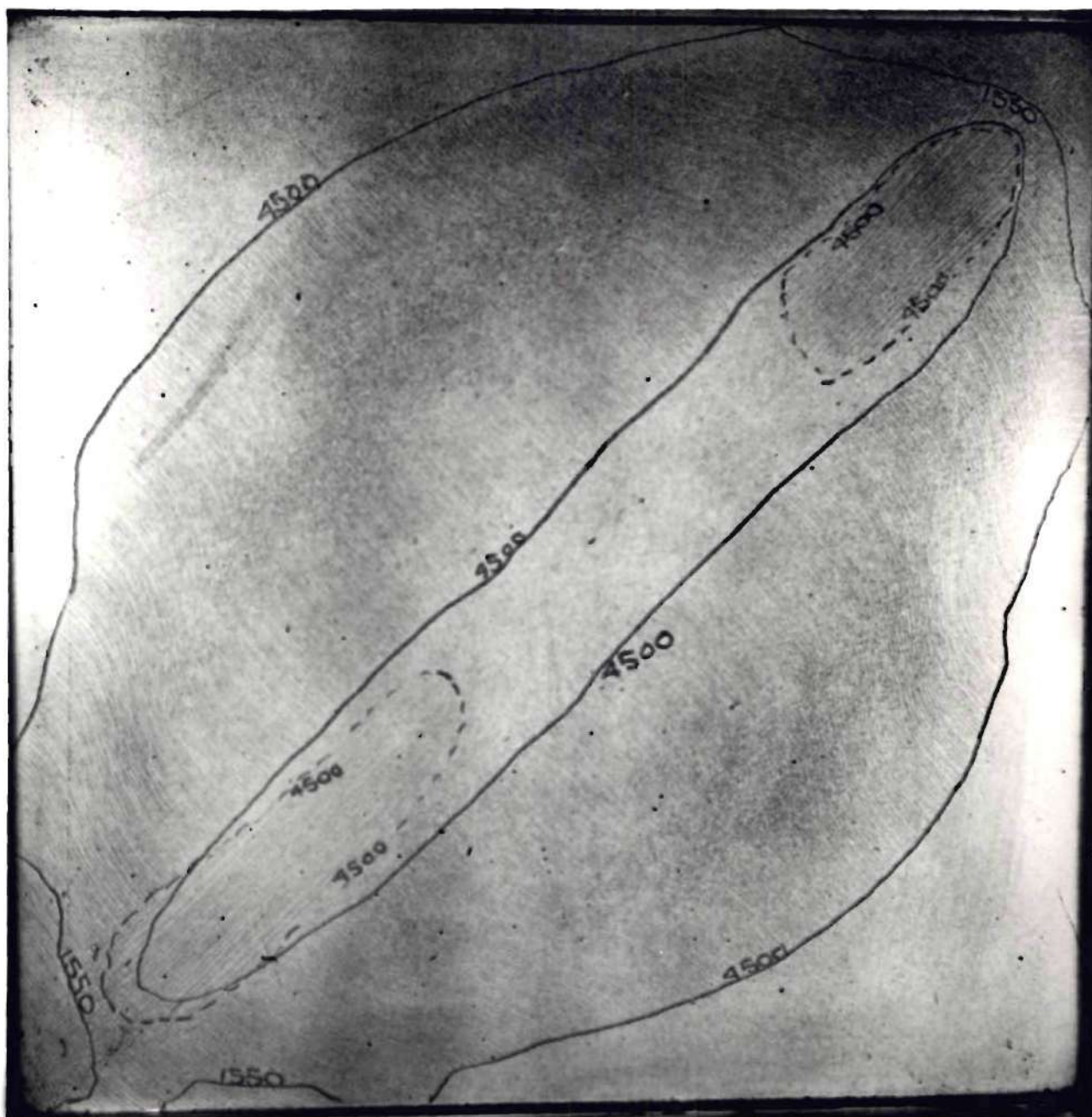


Figure 5. Stress pattern, 0.040 panel, rear.
Sensitivity 0.00092 in./in.
Stresscoat No. ST-1208.

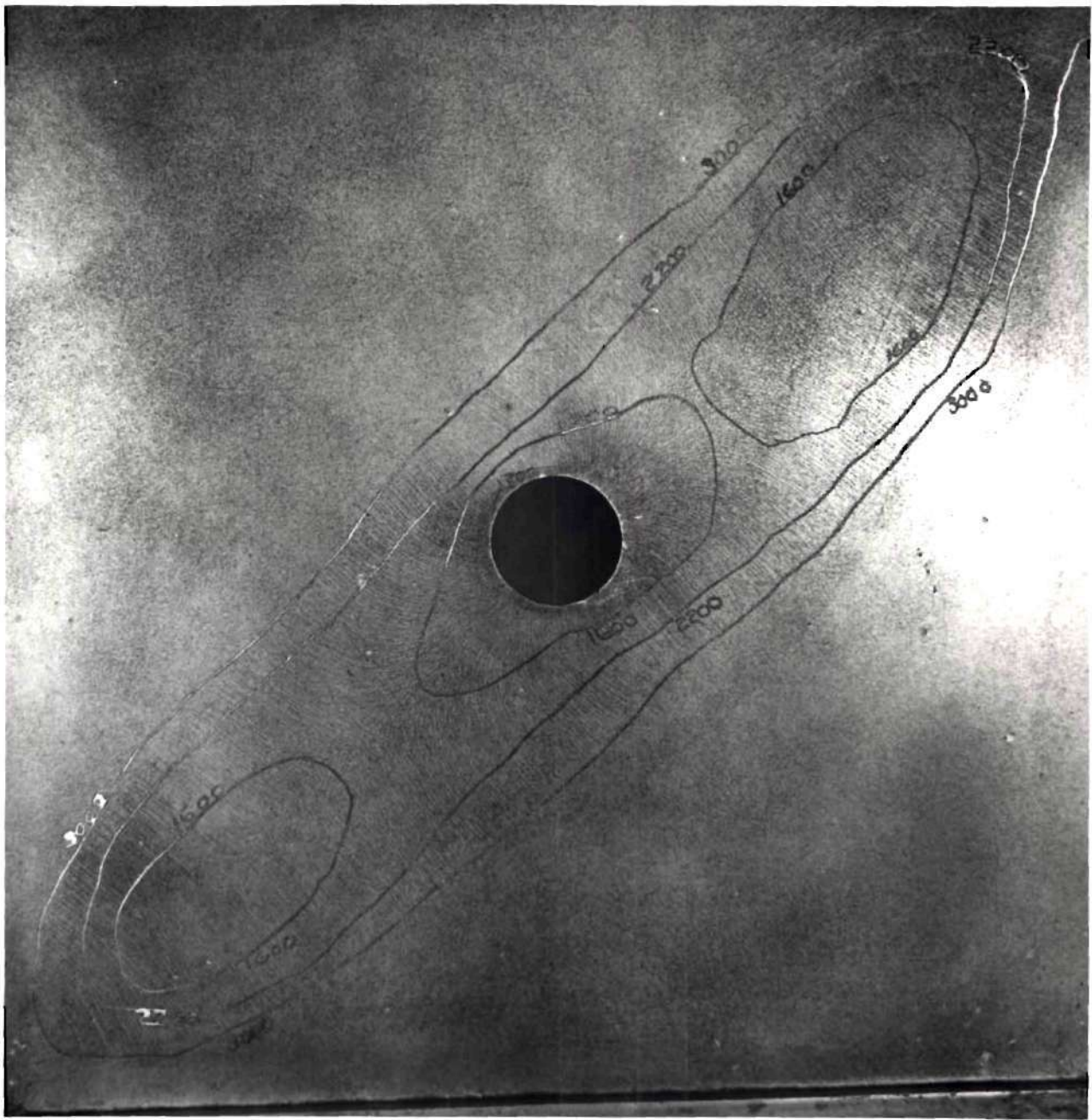


Figure 6. Stress pattern, 0.040 panel, front.
1 in. diameter access hole.
Sensitivity 0.00100 in./in.
Stresscoat No. ST-1208.

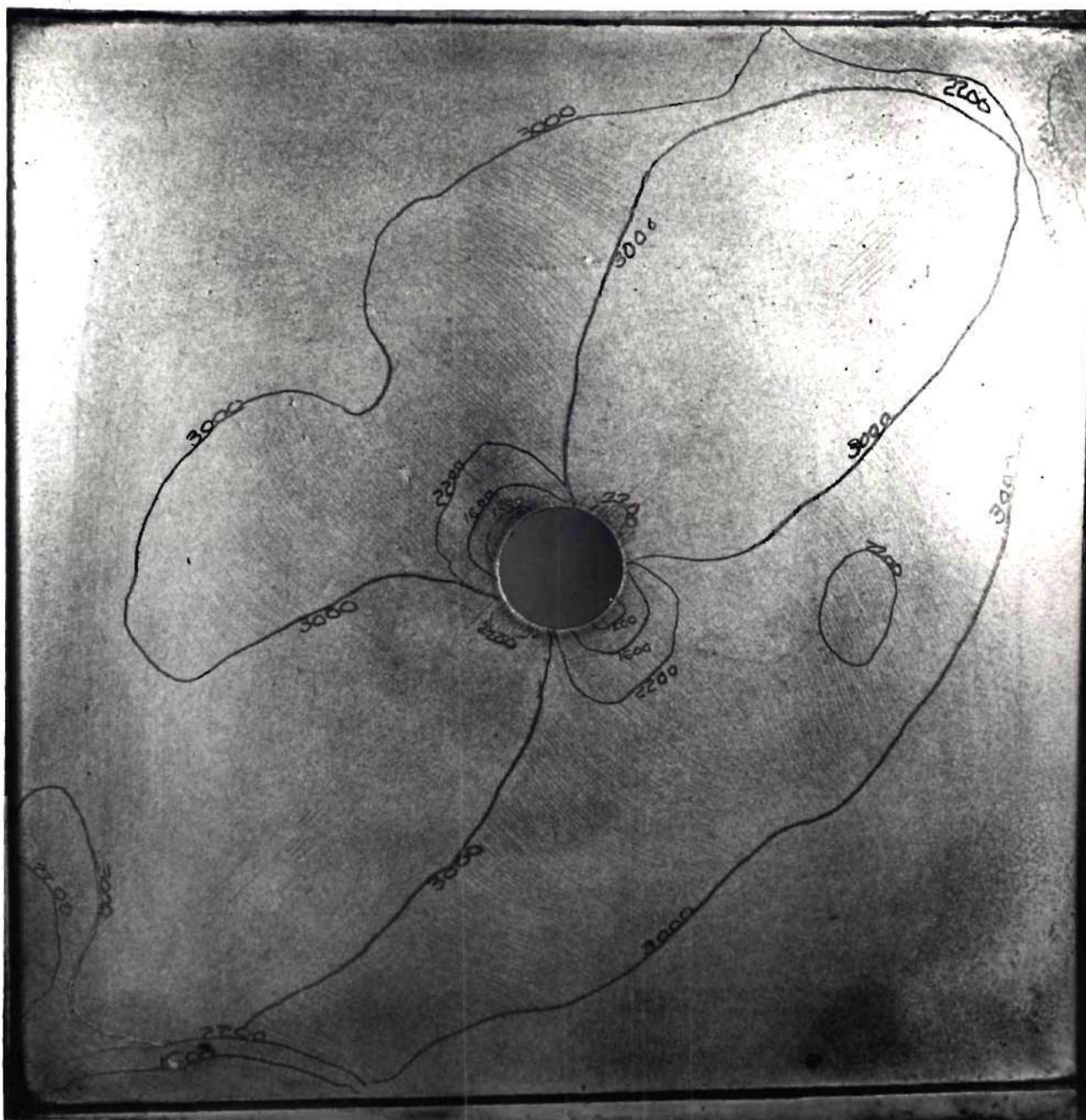


Figure 7. Stress pattern, 0.040 panel, rear.
1 in. diameter access hole.
Sensitivity 0.00100 in./in.
Stresscoat No. ST-1208.

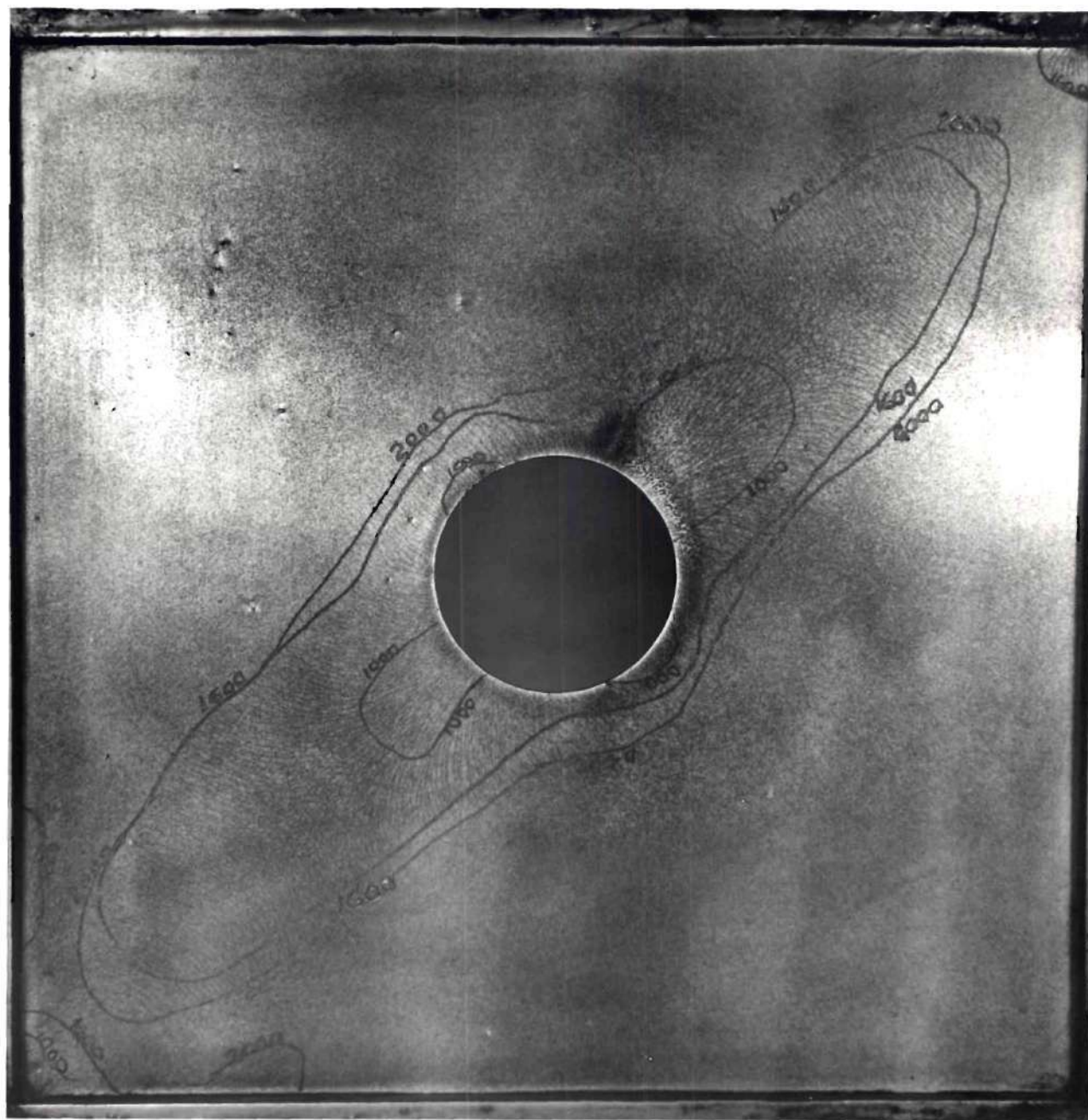


Figure 8. Stress pattern, 0.040 panel, front.
2 in. diameter access hole.
Sensitivity 0.00077 in./in.
Stresscoat No. ST-1208.

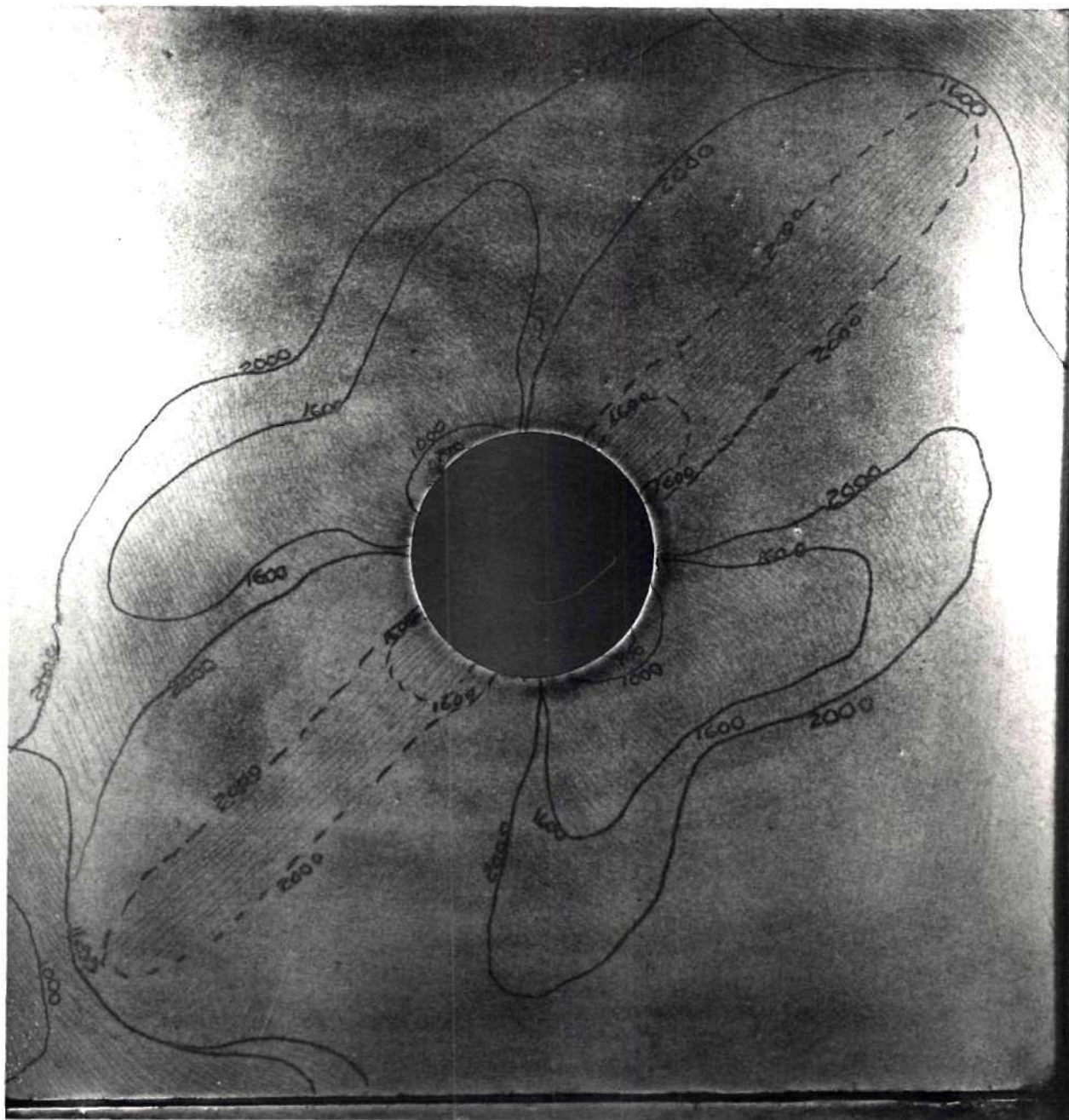


Figure 9. Stress pattern, 0.040 panel, rear.
2 in. diameter access hole.
Sensitivity 0.00077 in./in.
Stresscoat No. ST-1208.

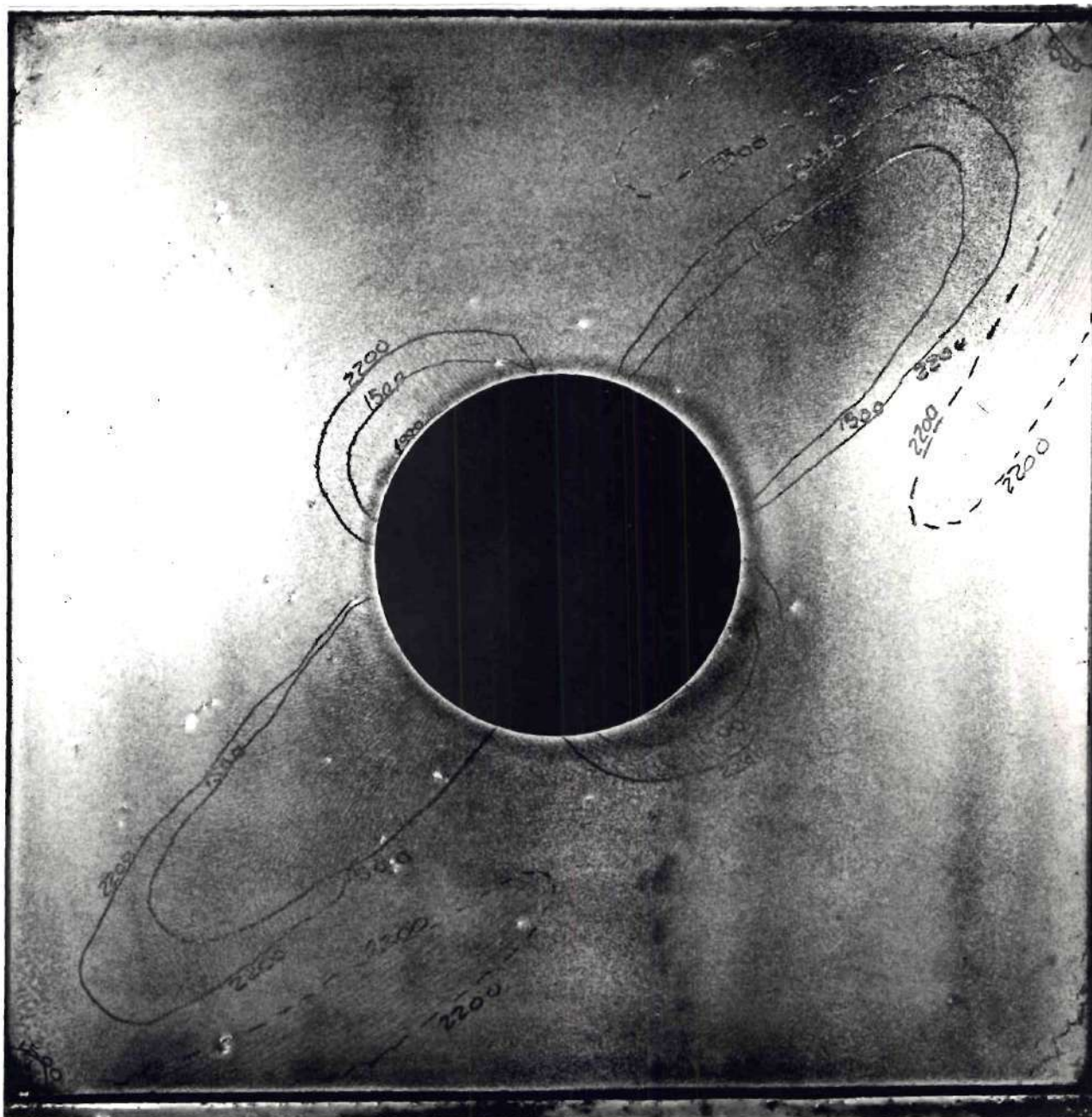


Figure 10. Stress pattern, 0.040 panel, front.
3 in. diameter access hole.
Sensitivity 0.00090 in./in.
Stresscoat No. ST-1208.

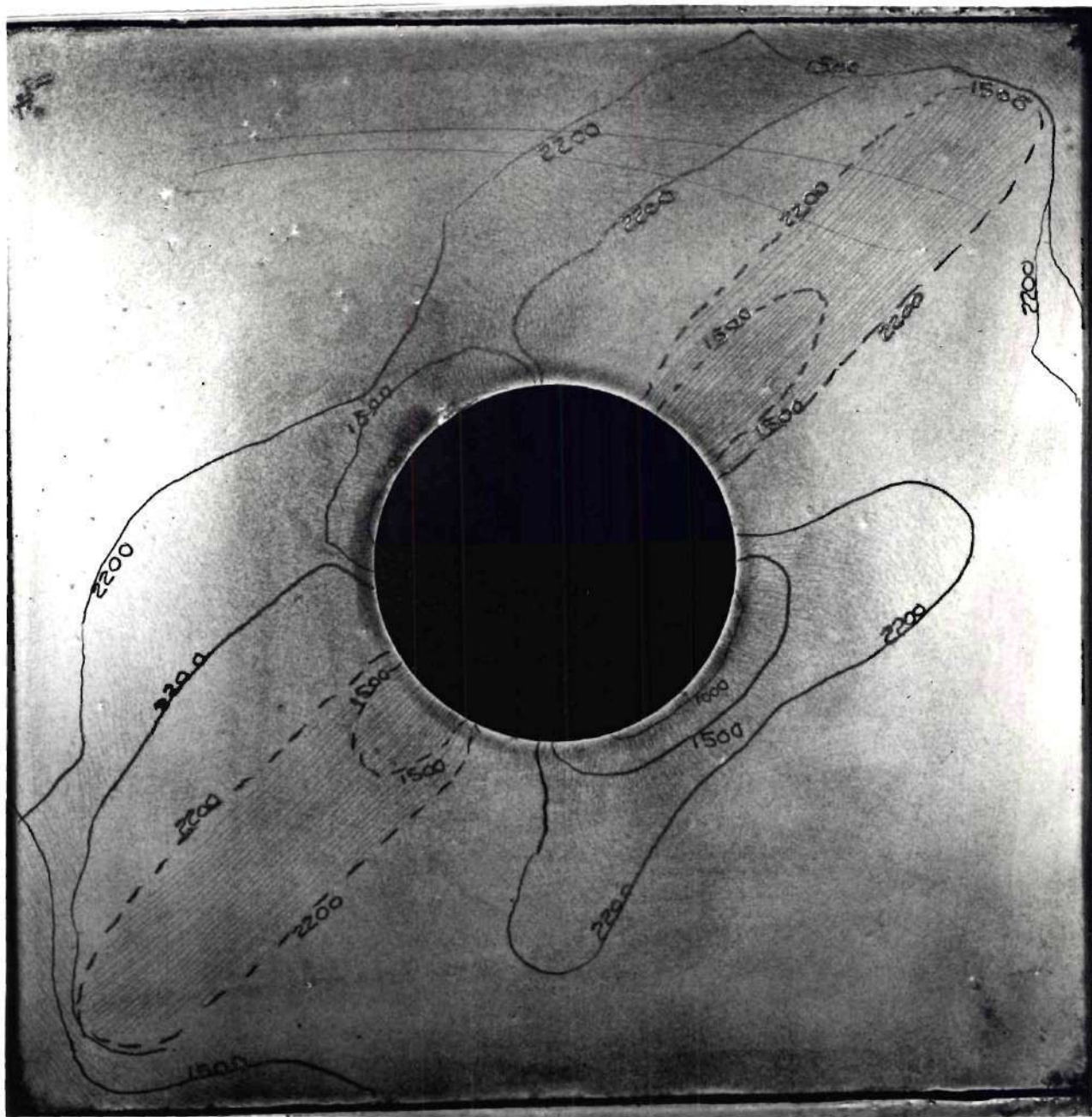


Figure 11. Stress pattern, 0.040 panel, rear.
3 in. diameter access hole.
Sensitivity 0.00090 in./in.
Stresscoat No. ST-1208.

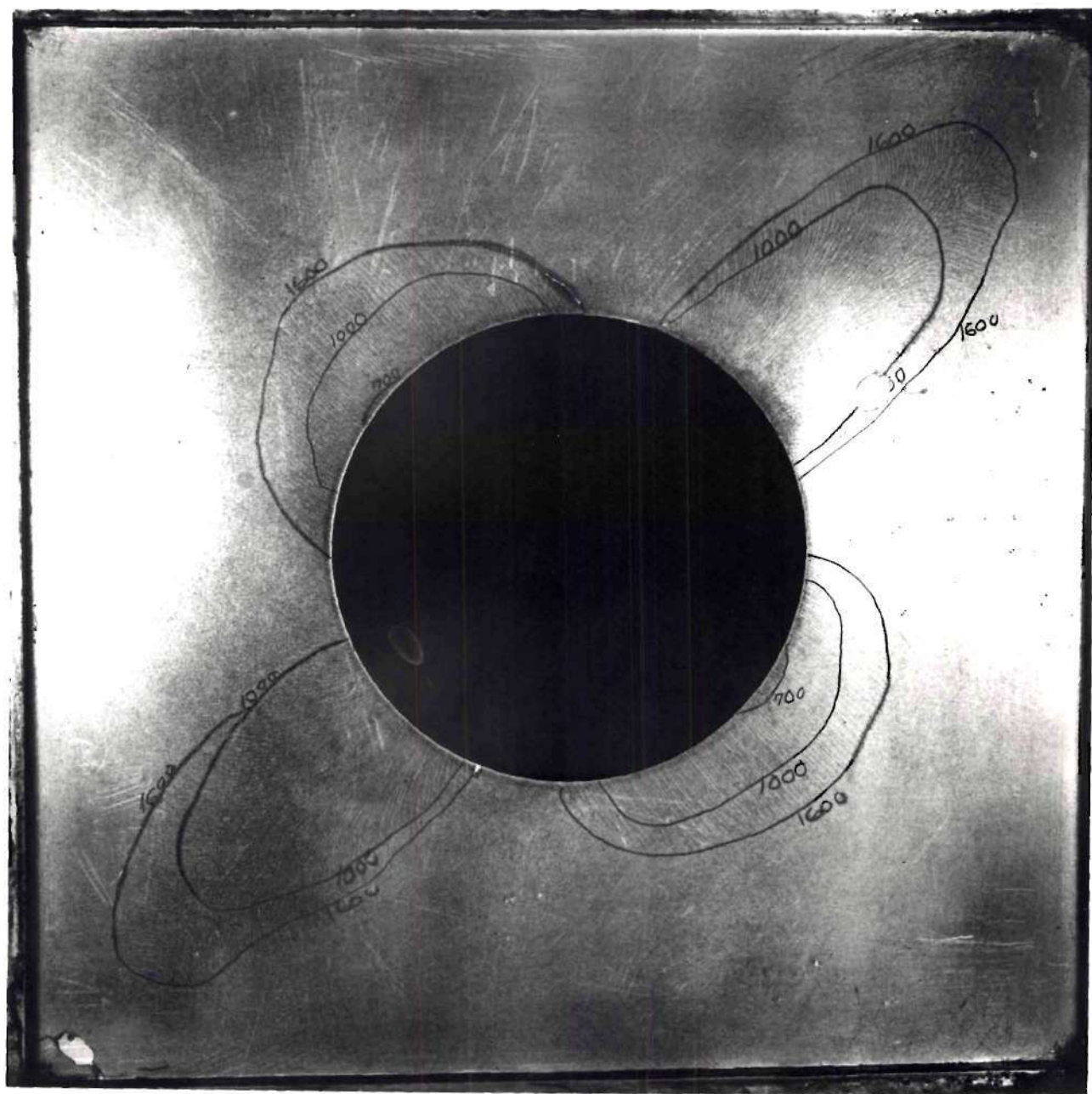


Figure 12. Stress pattern, 0.040 panel, front.
4 in. diameter access hole.
Sensitivity 0.00071 in./in.
Stresscoat No. ST-1208.

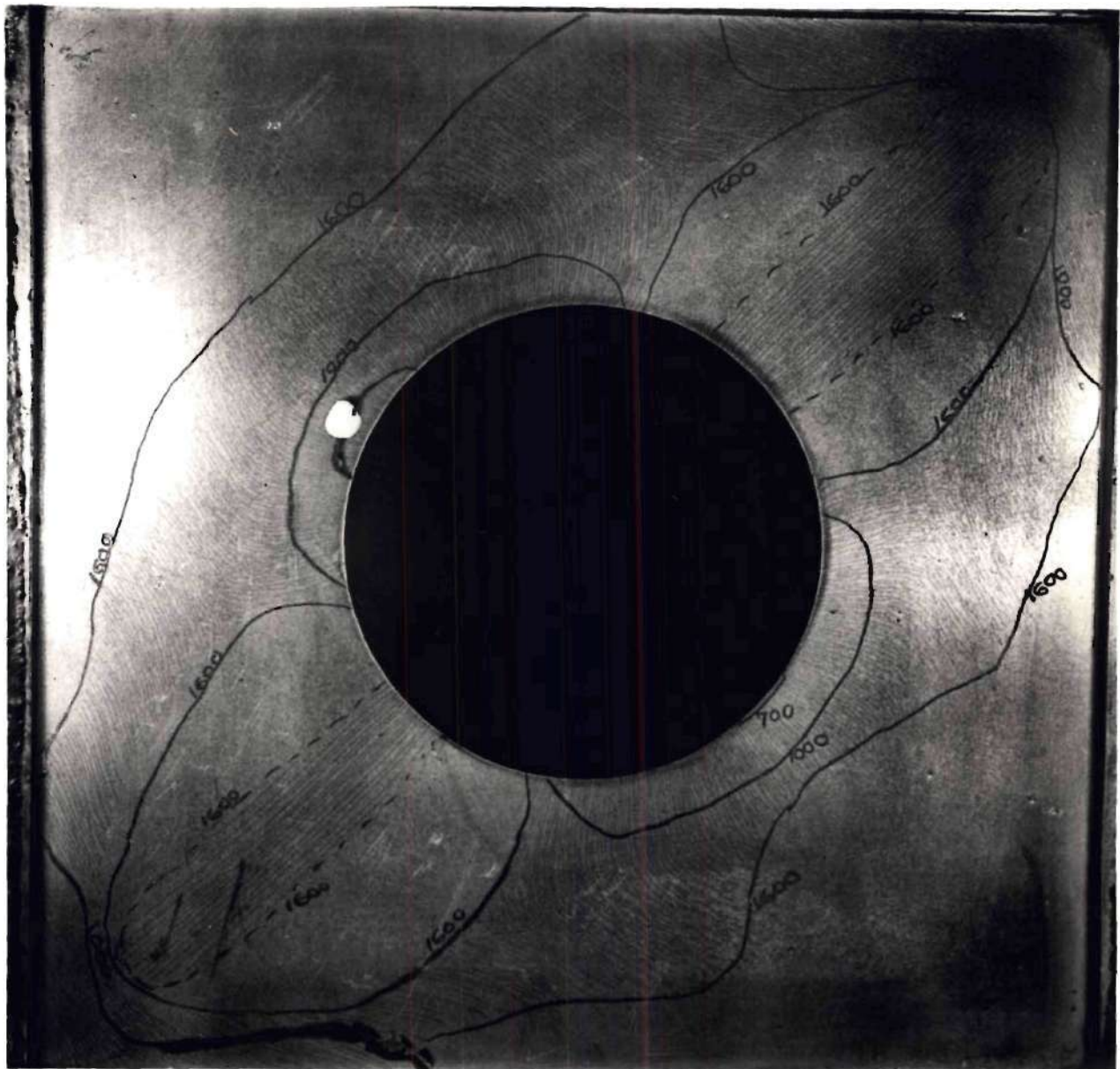


Figure 13. Stress pattern, 0.040 panel, rear.
4 in. diameter access hole.
Sensitivity 0.00071 in./in.
Stresscoat No. ST-1208.

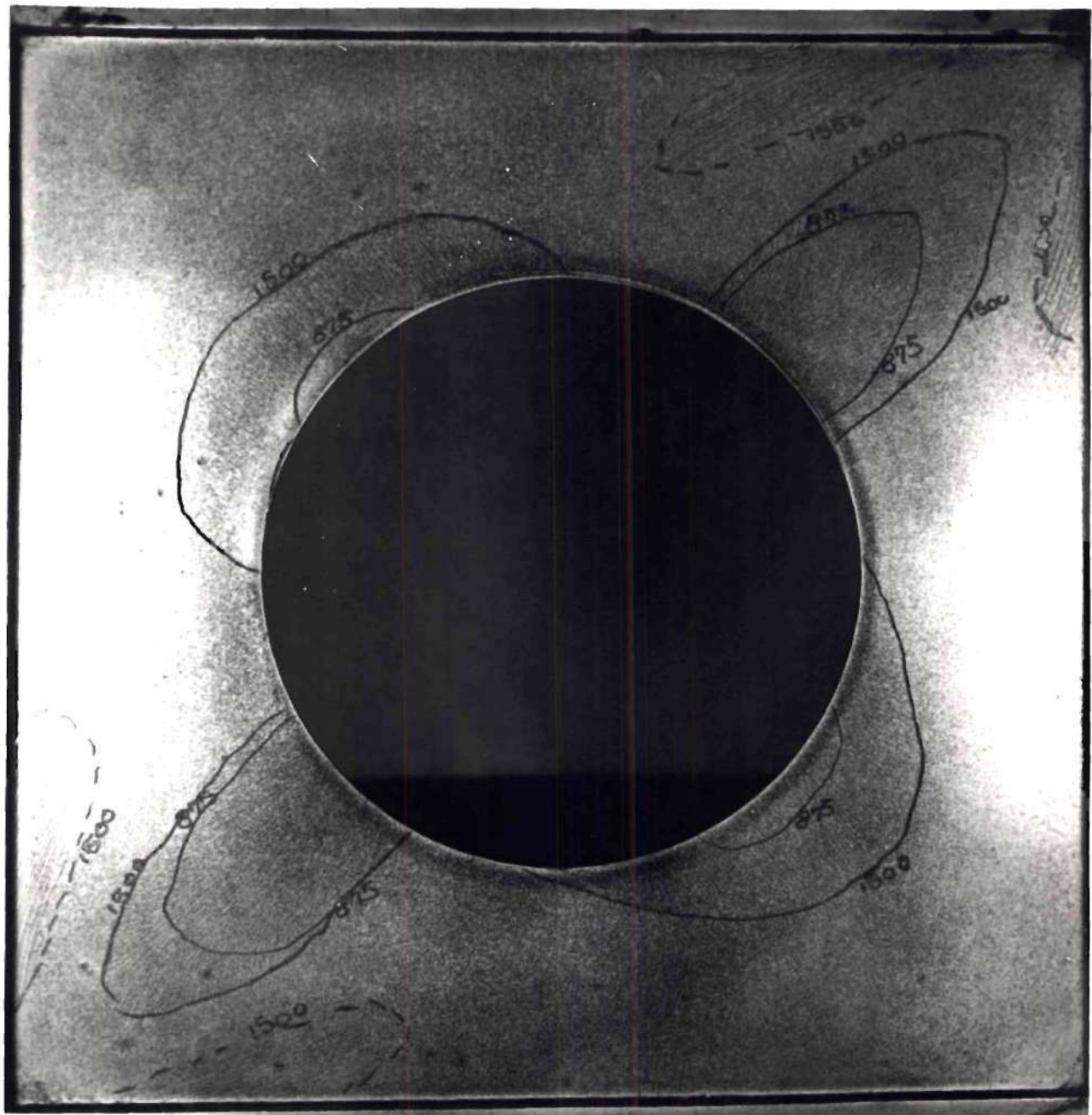


Figure 14. Stress pattern, 0.040 panel, front.
5 in. diameter access hole.
Sensitivity 0.00102 in./in.
Stresscoat No. ST-1208.

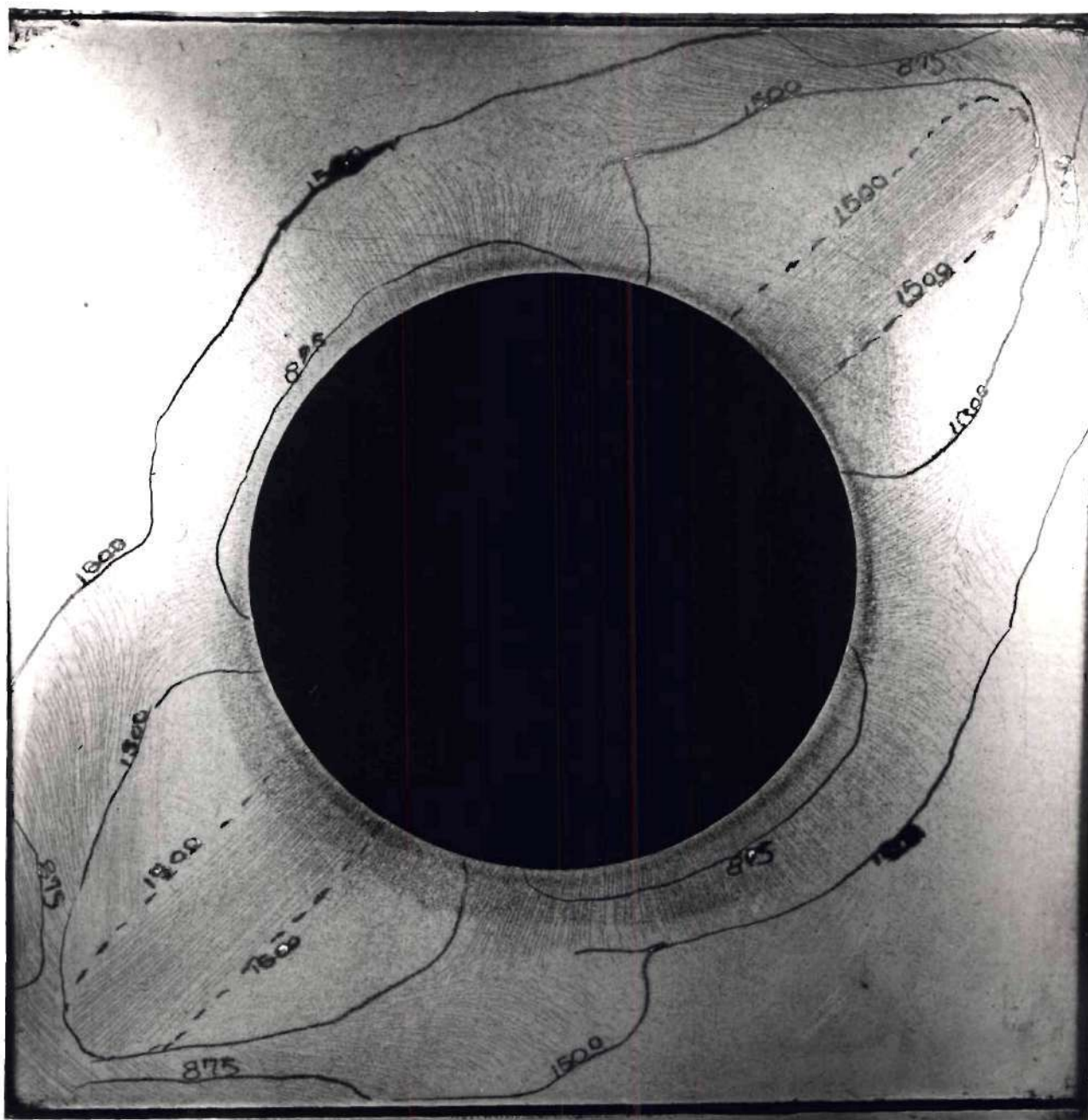


Figure 15. Stress pattern, 0.040 panel, rear.
5 in. diameter access hole.
Sensitivity 0.00102 in./in.
Stresscoat No. ST-1208.

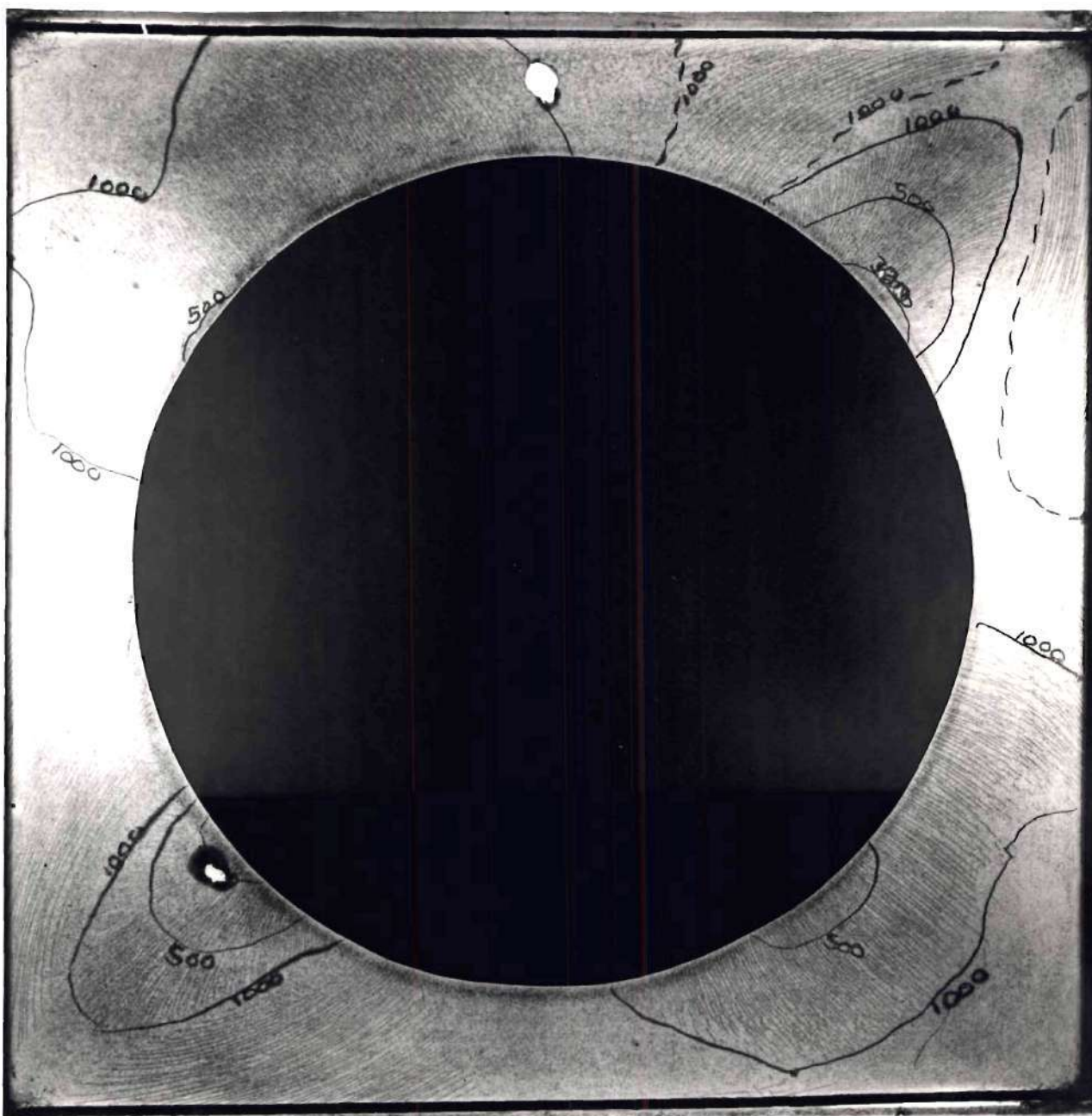


Figure 16. Stress pattern, 0.040 panel, front.
7 in. diameter access hole.
Sensitivity 0.00067 in./in.
Stresscoat No. ST-1208.

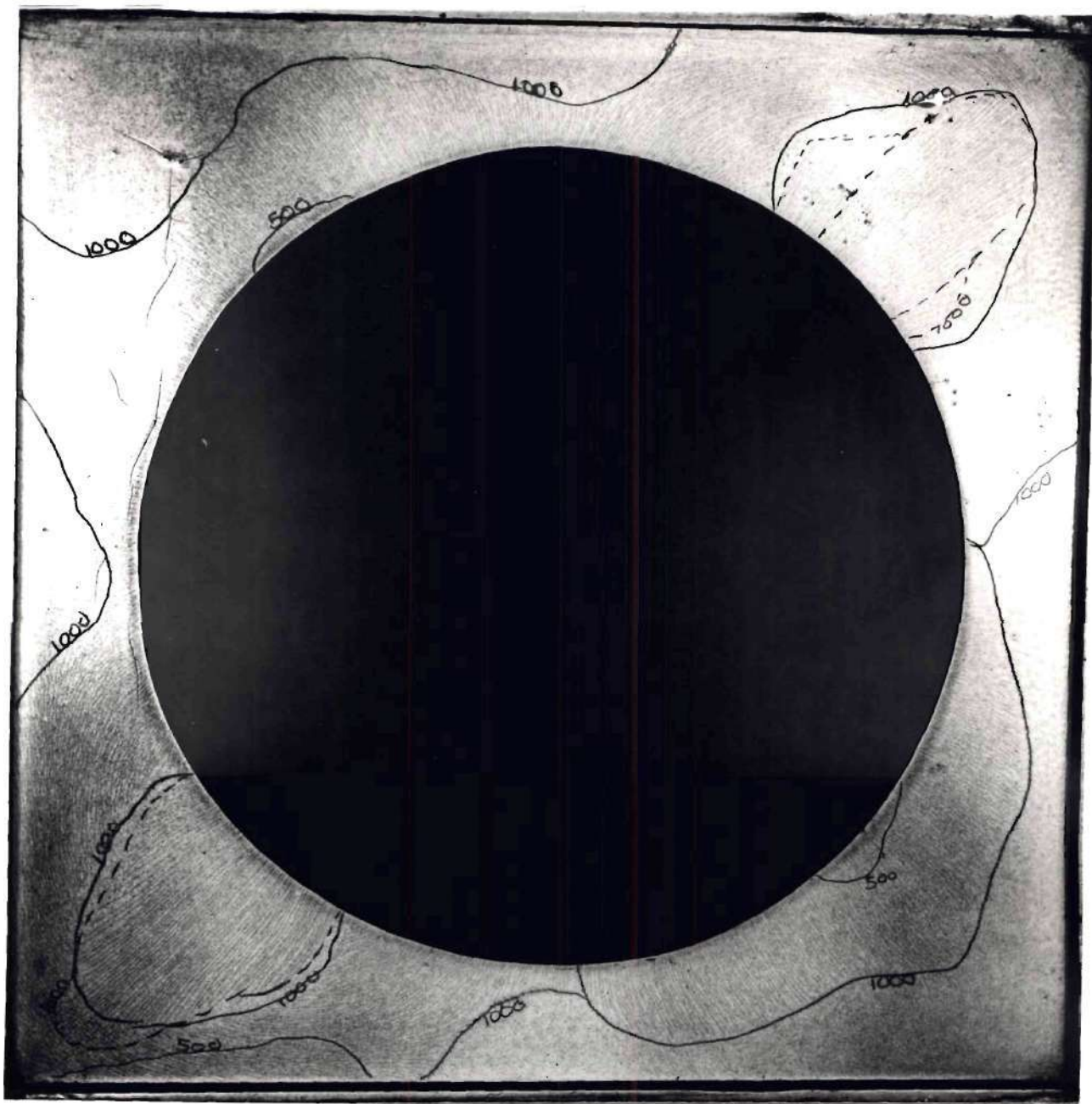


Figure 17. Stress pattern, 0.040 panel, rear.
7 in. diameter access hole.
Sensitivity 0.00067 in./in.
Stresscoat No. ST-1208.

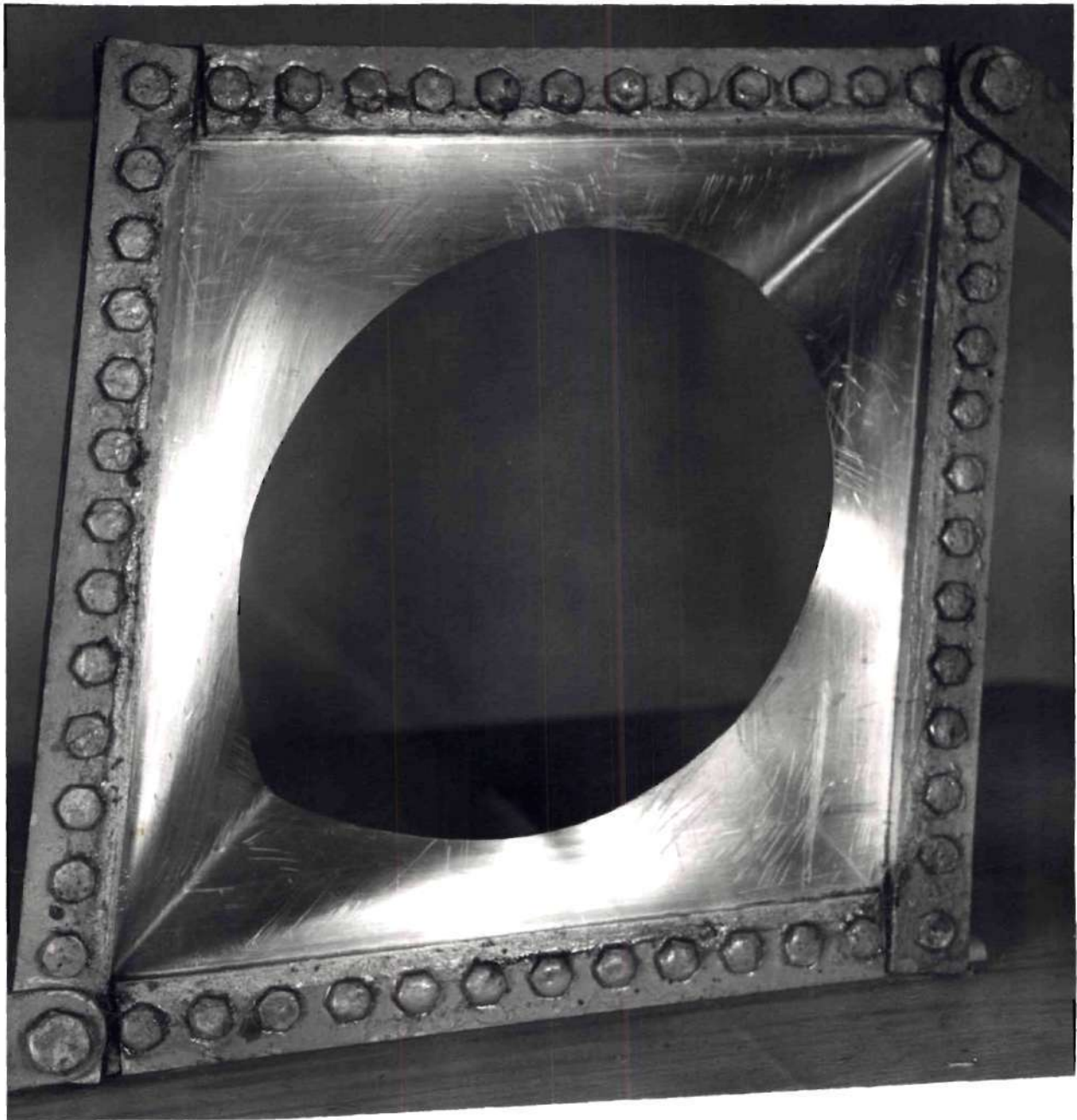


Figure 18. Rupture at lower right hand corner.
7 in. diameter access hole.

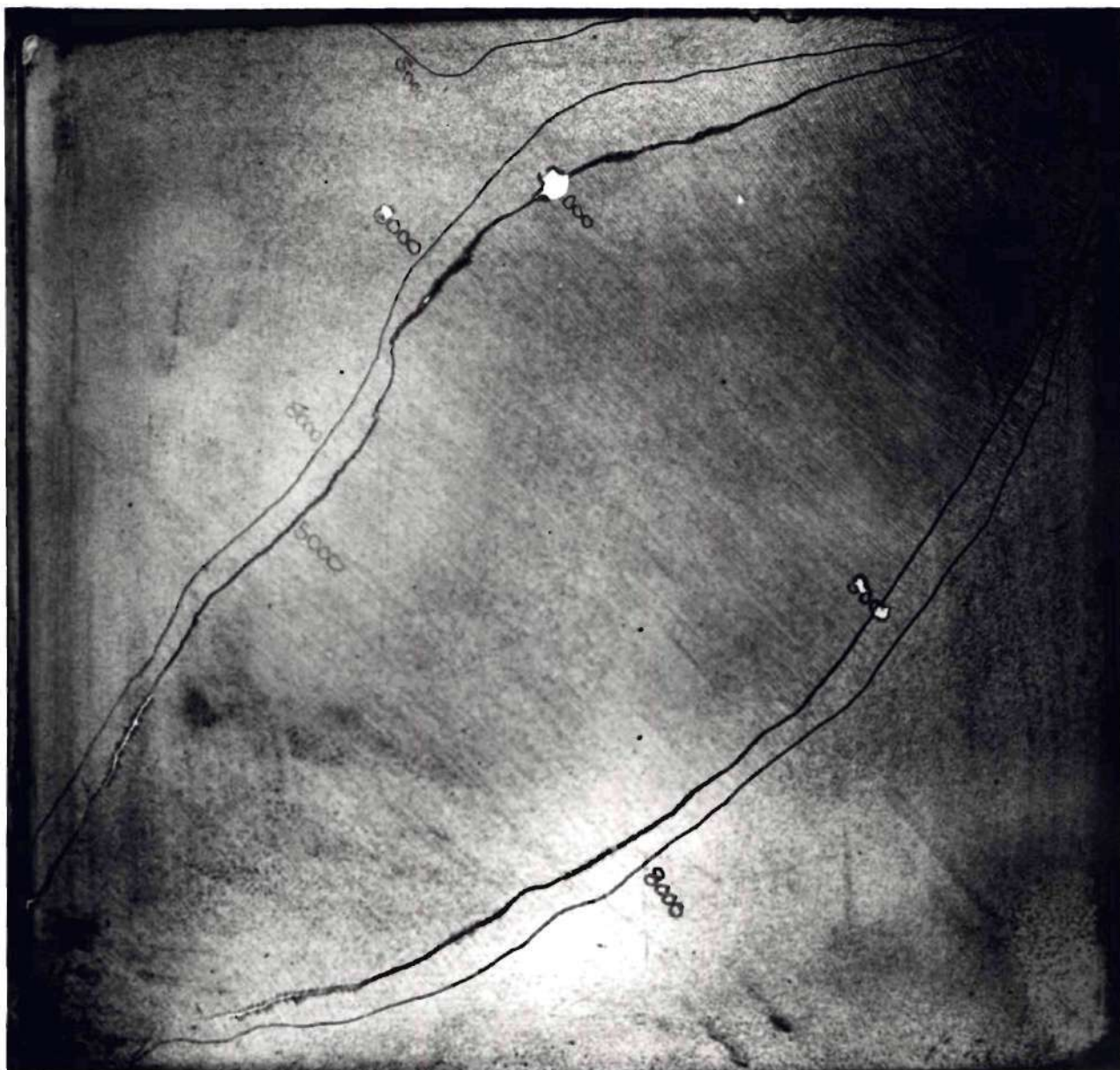


Figure 19. Stress pattern, 0.064 panel, front.
Sensitivity 0.00093 in./in.
Stresscoat No. ST-1207.

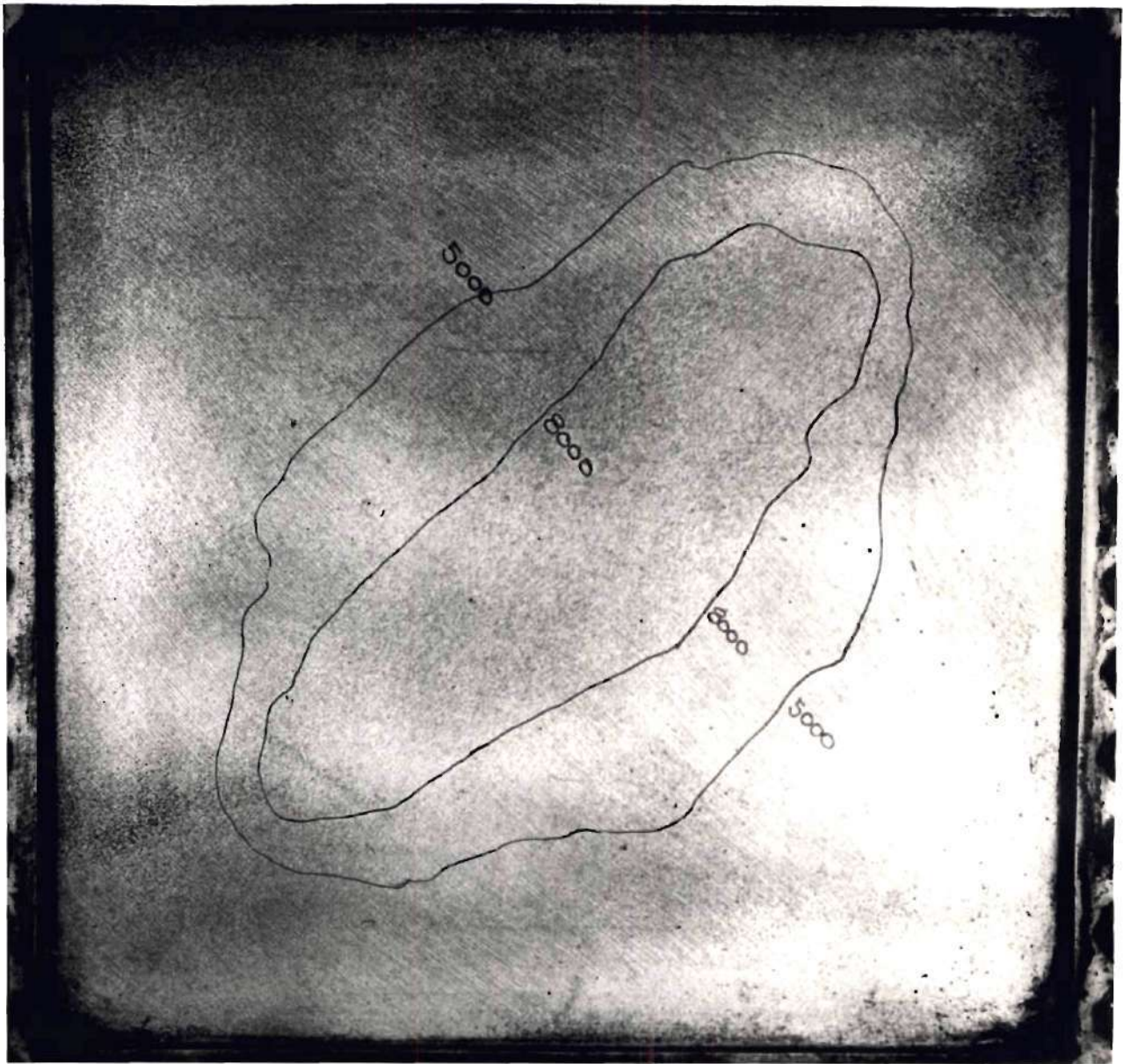


Figure 20. Stress pattern, 0.064 panel, rear.
Sensitivity 0.00093 in./in.
Stresscoat No. ST-1207.

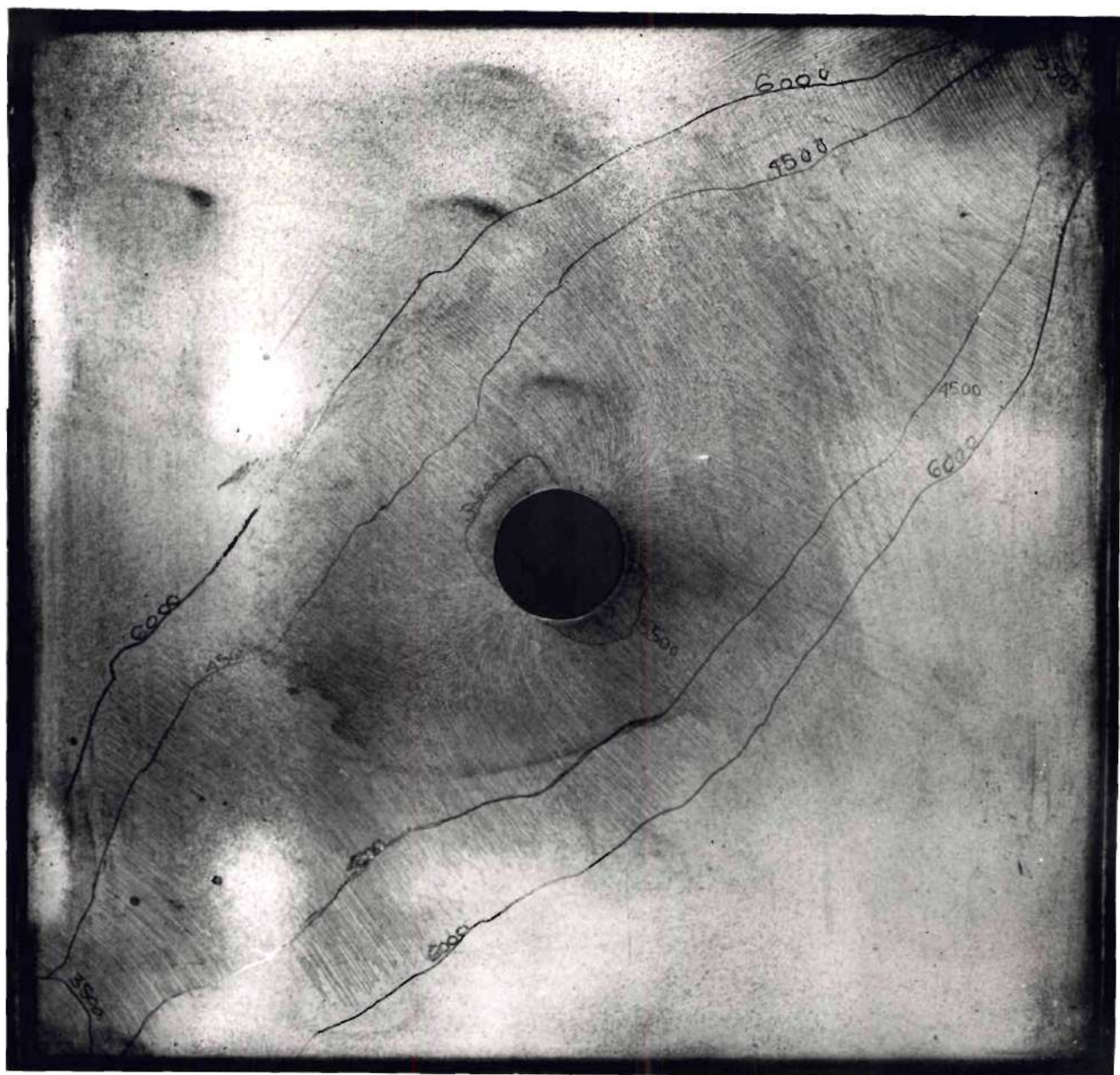


Figure 21. Stress pattern, 0.064 panel, front.
1 in. diameter access hole.
Sensitivity 0.00170 in./in.
Stresscoat No. ST-1205.

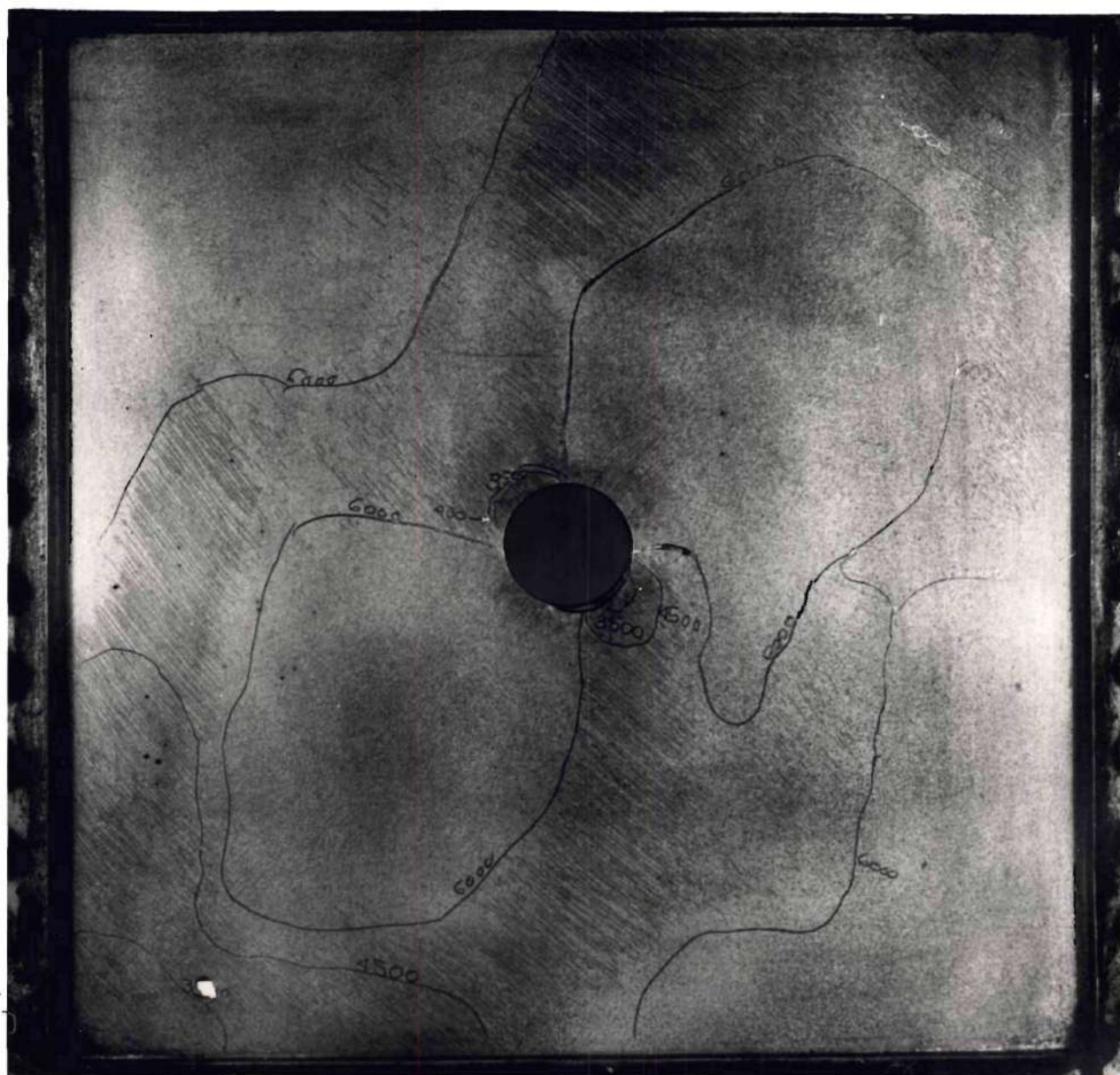


Figure 22. Stress pattern, 0.064 panel, rear.
1 in. diameter access hole.
Sensitivity 0.00170 in./in.
Stresscoat No. ST-1205.

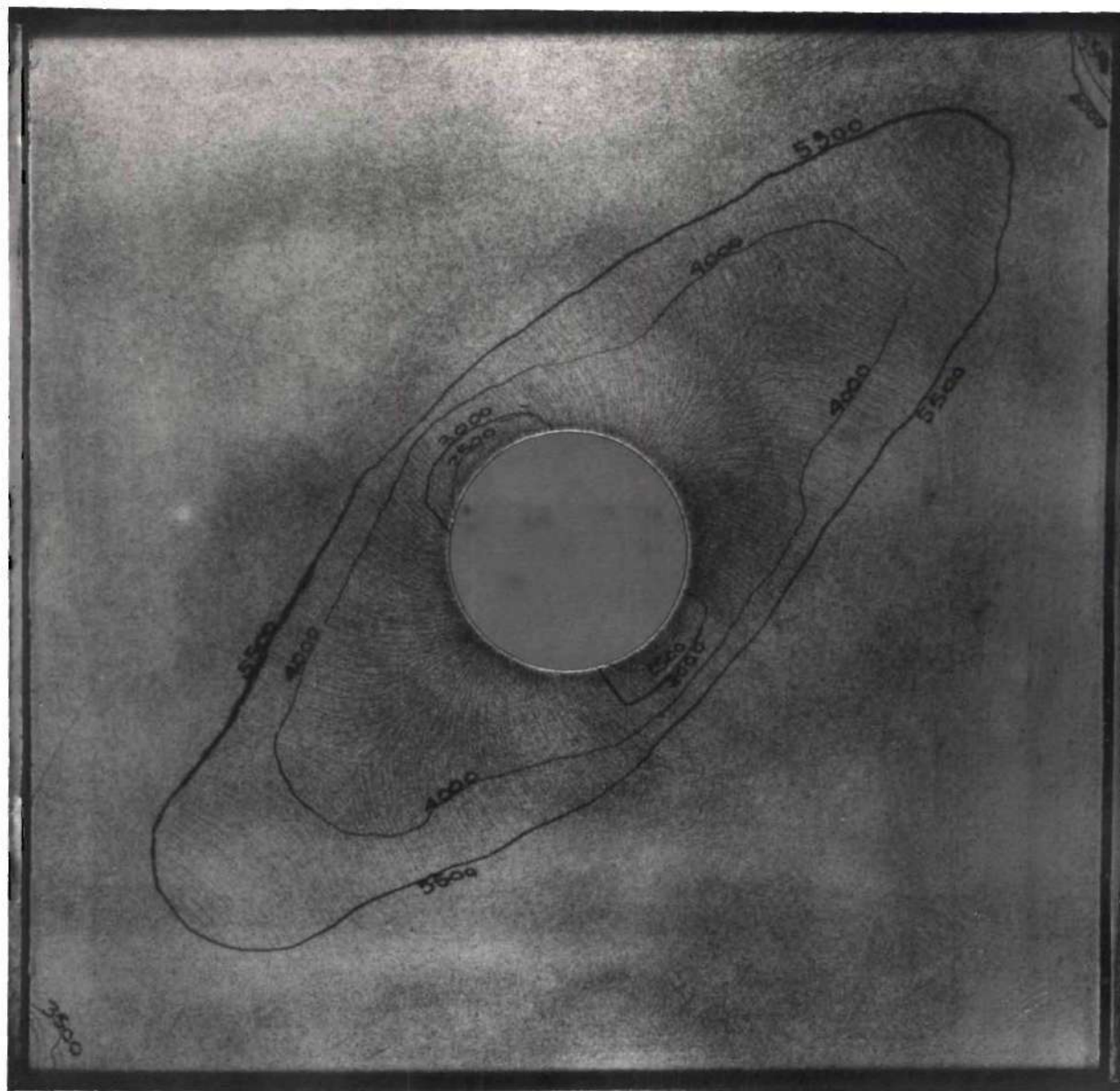


Figure 23. Stress pattern, 0.064 panel, front.
2 in. diameter access hole.
Sensitivity 0.00125 in./in.
Stresscoat No. ST-1205.

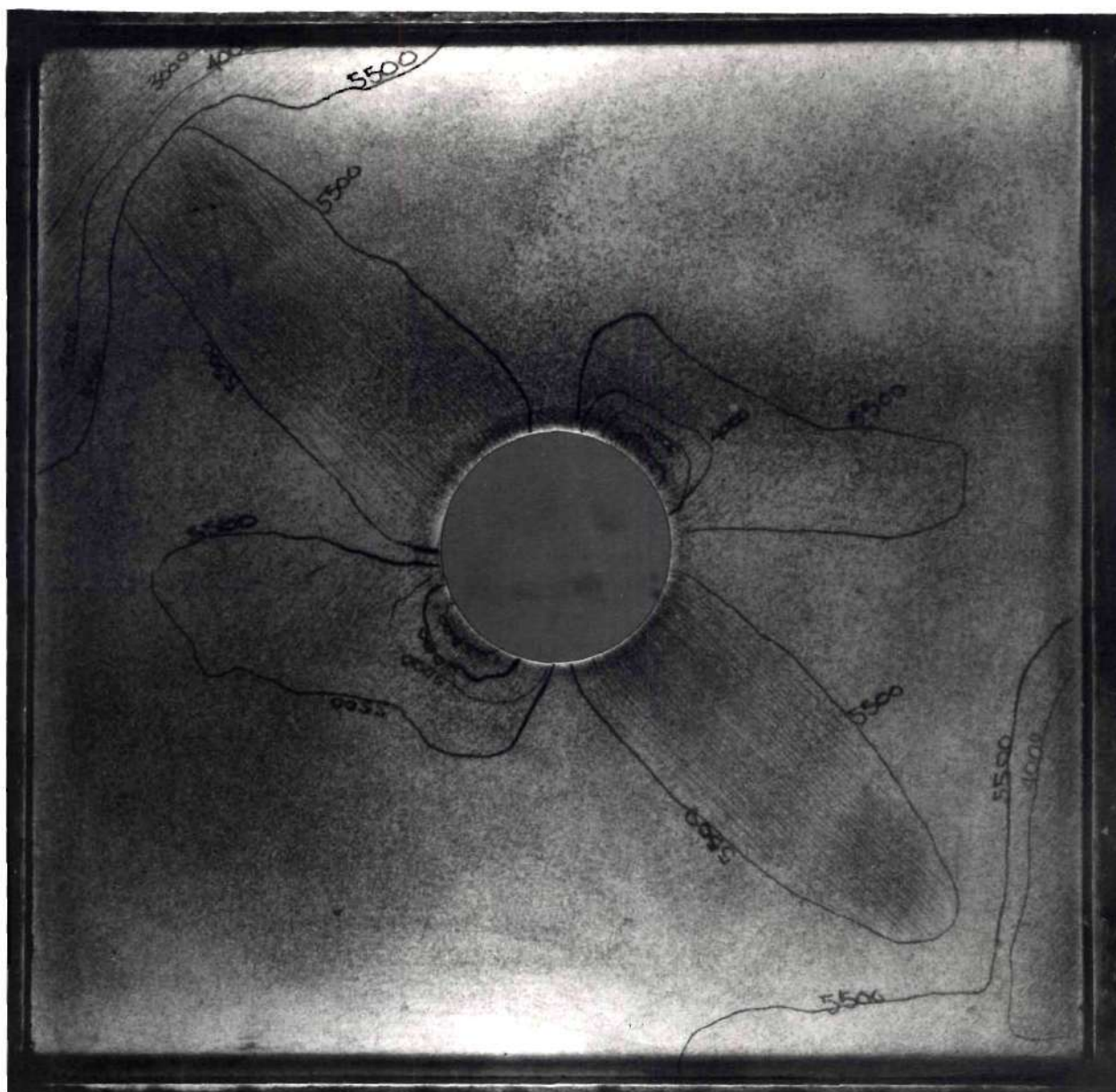


Figure 24. Stress pattern, 0.064 panel, rear.
2 in. diameter access hole.
Sensitivity 0.00125 in./in.
Stresscoat No. ST-1205.

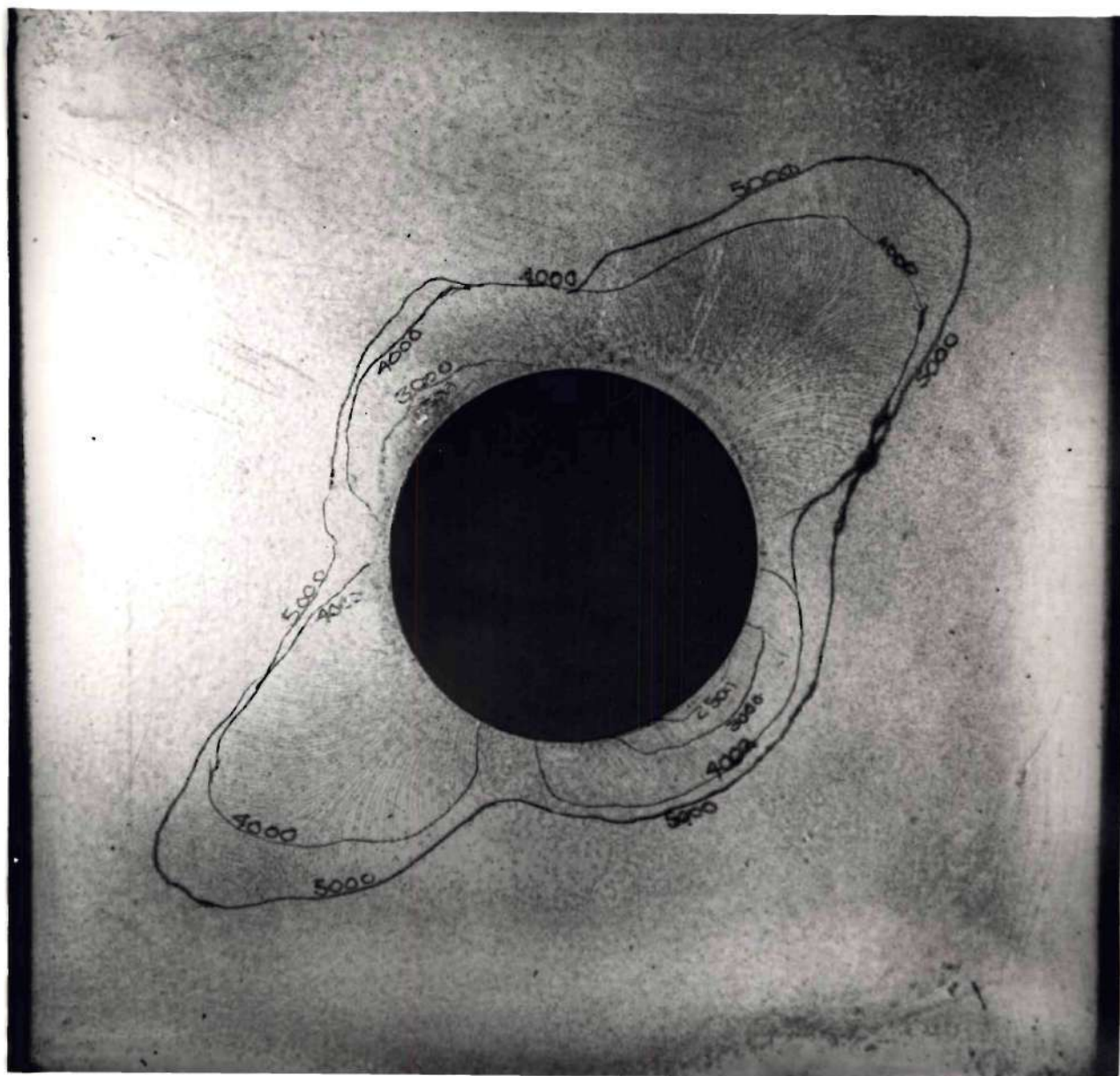


Figure 25. Stress pattern, 0.064 panel, front.
3 in. diameter access hole.
Sensitivity 0.00110 in./in.
Stresscoat No. ST-1206.

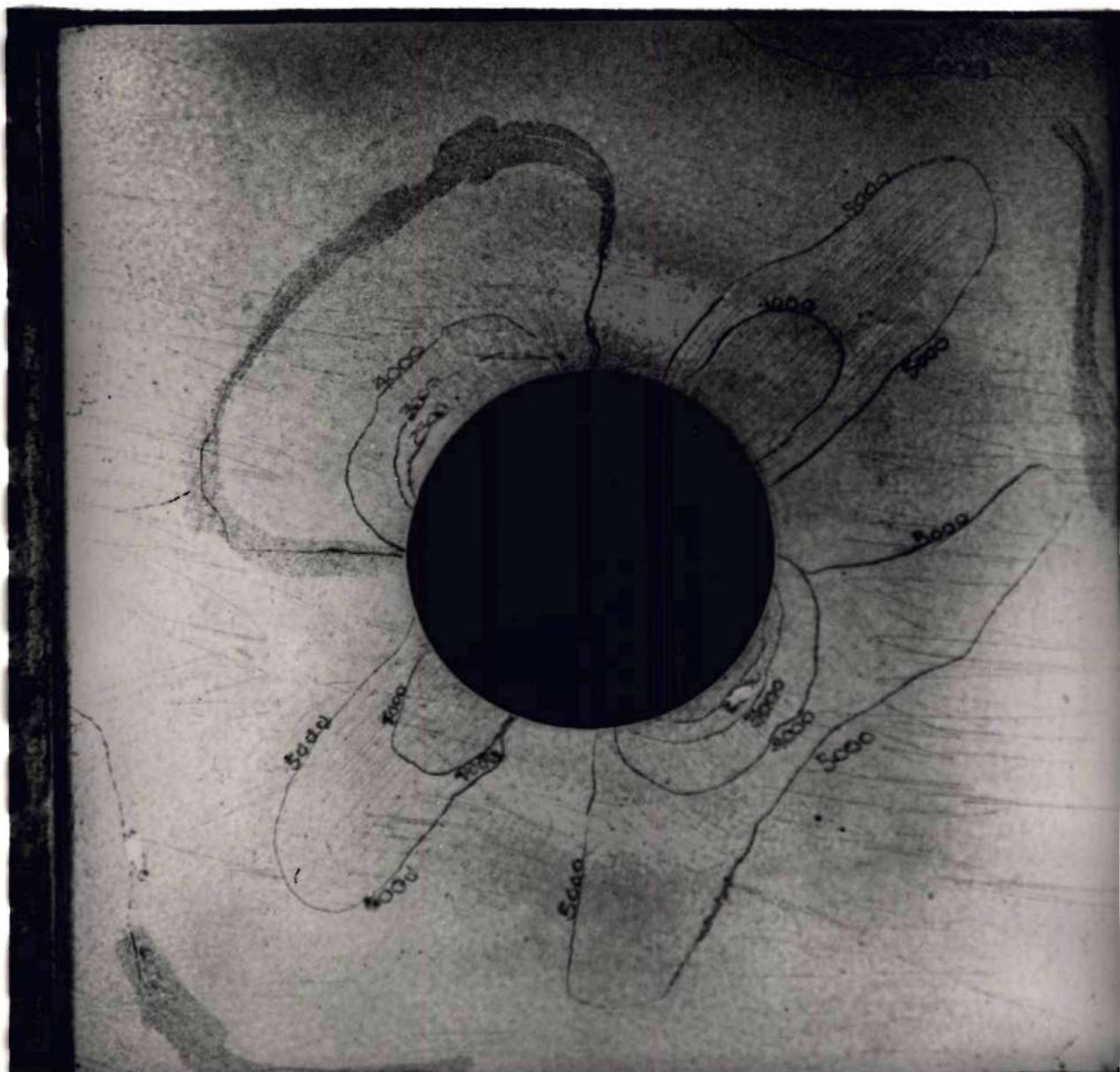


Figure 26. Stress pattern, 0.064 panel, rear.
3 in. diameter access hole.
Sensitivity 0.00110 in./in.
Stresscoat No. ST-1206.

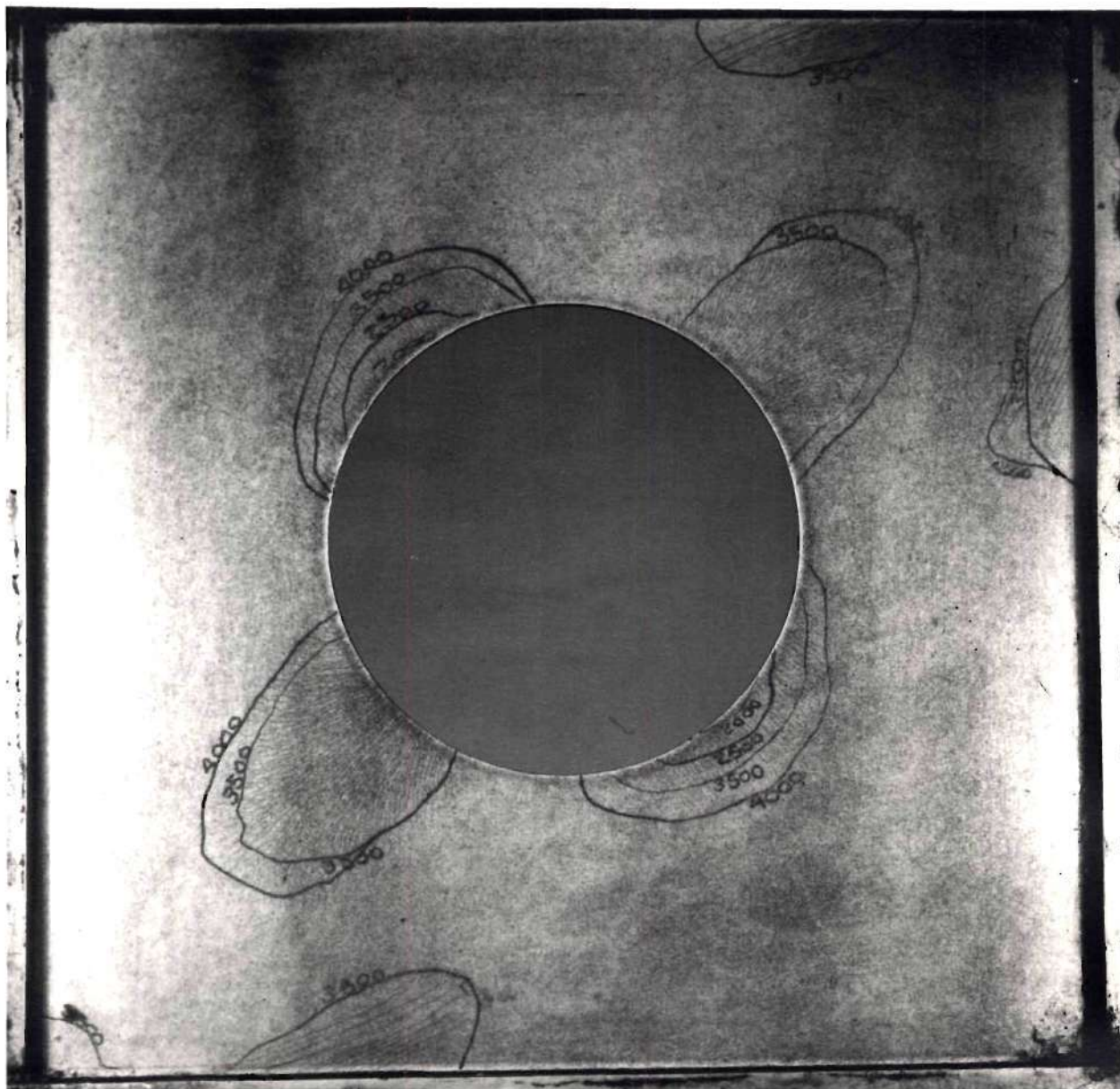


Figure 27. Stress pattern, 0.064 panel, front.
4 in. diameter access hole.
Sensitivity 0.00115 in./in.
Stresscoat No. ST-1207.

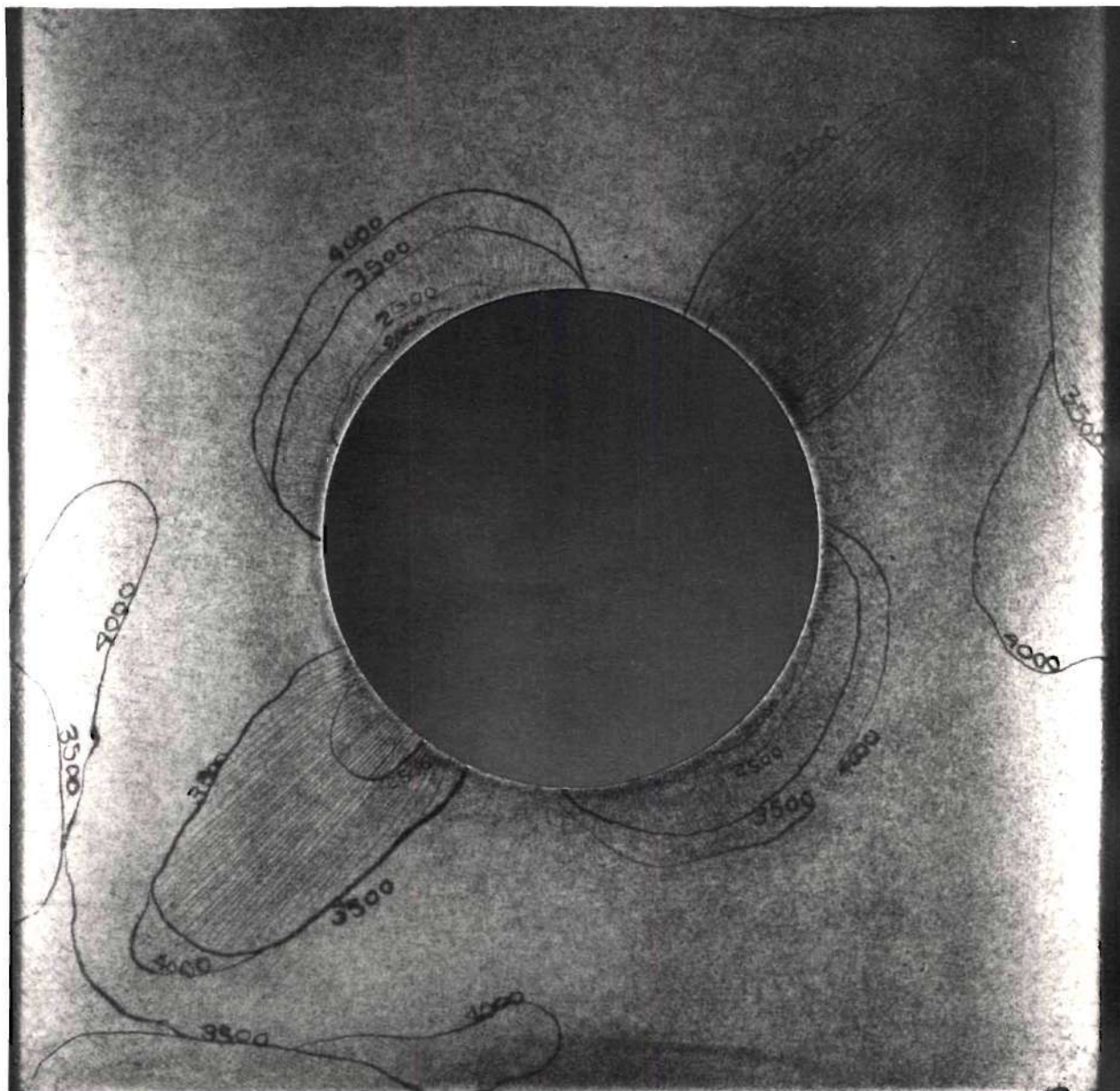


Figure 28. Stress pattern, 0.064 panel, rear.
4 in. diameter access hole.
Sensitivity 0.00115 in./in.
Stresscoat No. ST-1207.

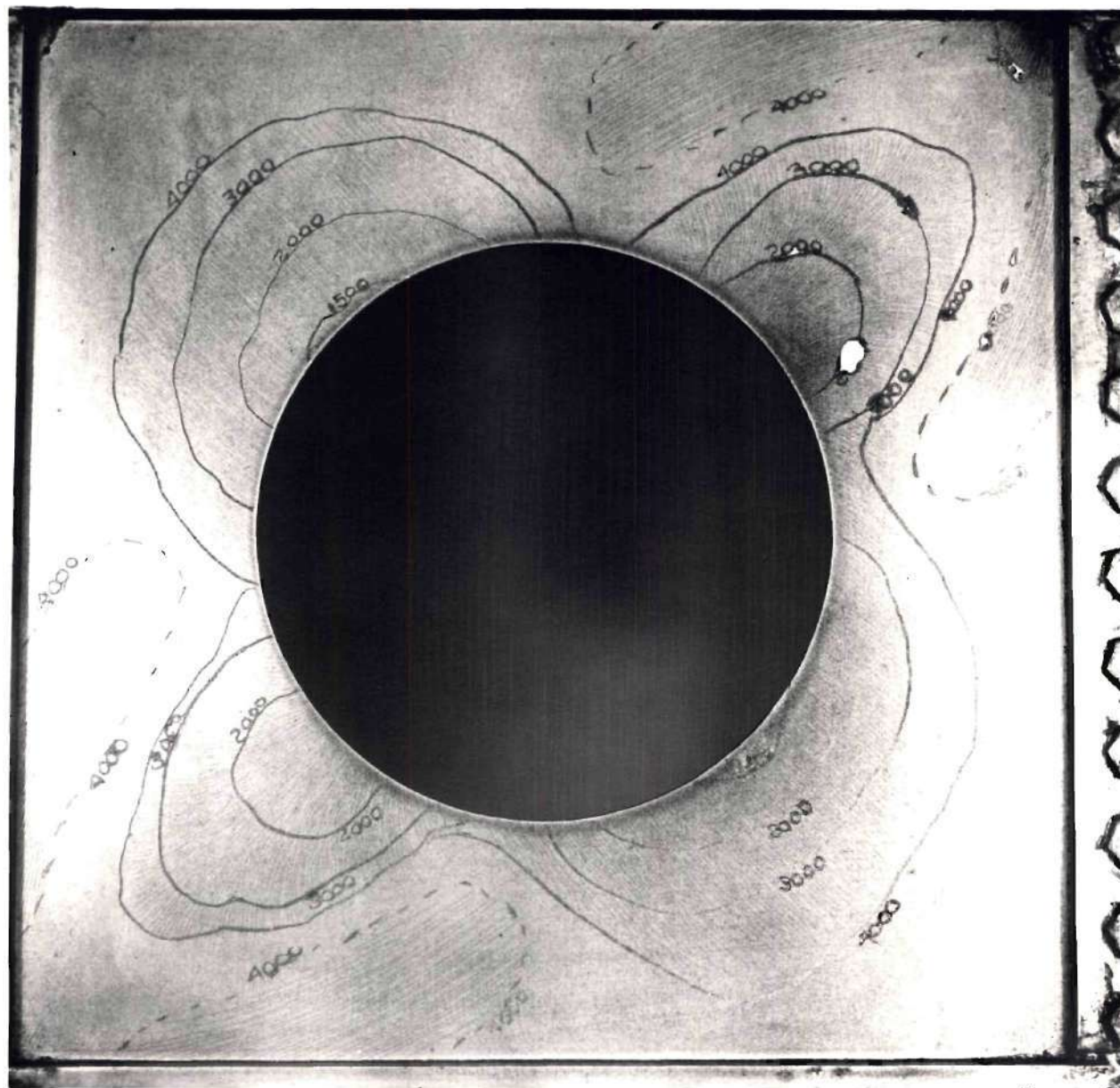


Figure 29. Stress pattern, 0.064 panel, front.
5 in. diameter access hole.
Sensitivity 0.00105 in./in.
Stresscoat No. ST-1208.

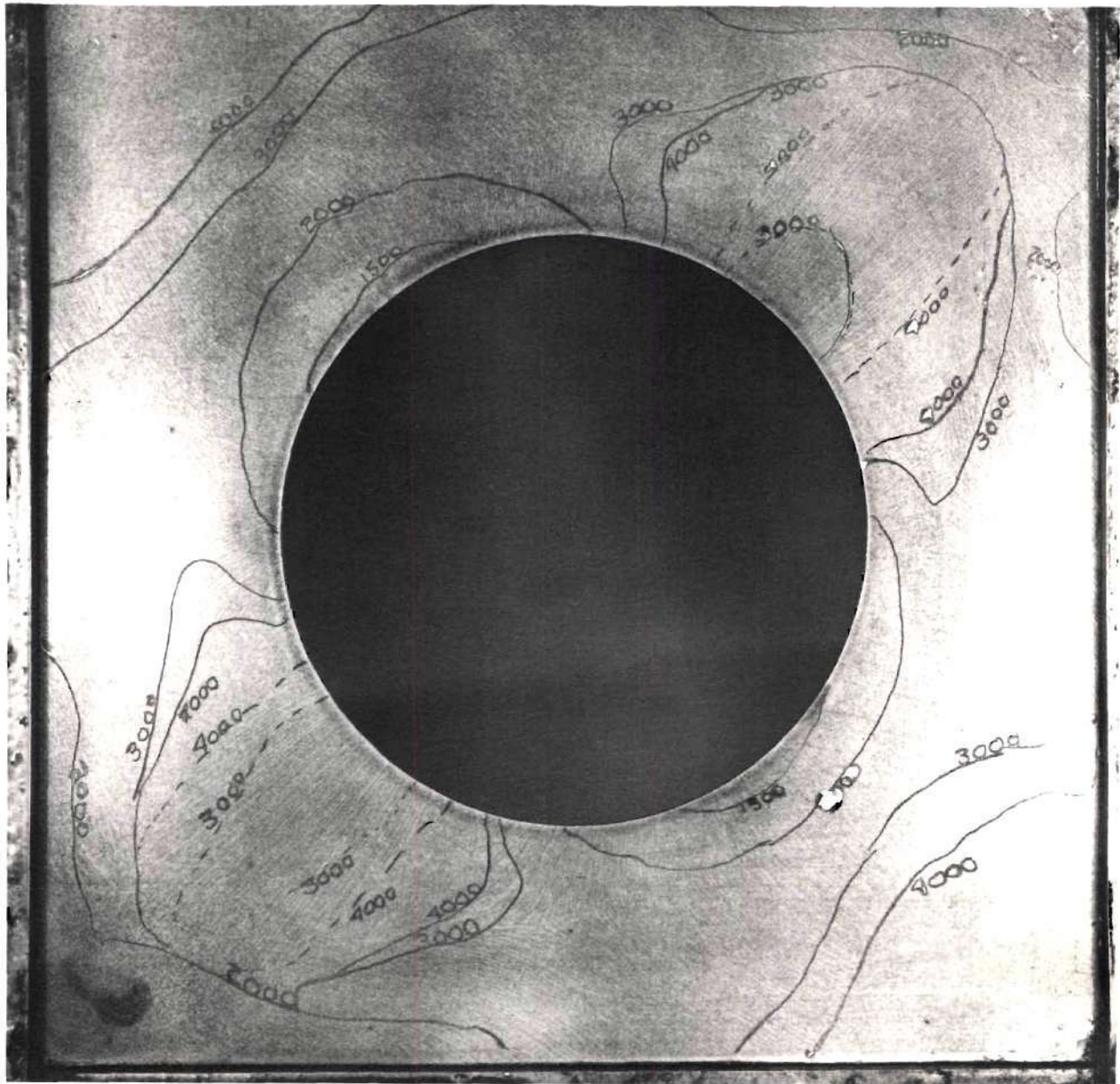


Figure 30. Stress pattern, 0.064 panel, rear.
5 in. diameter access hole.
Sensitivity 0.00105 in./in.
Stresscoat No. ST-1208.

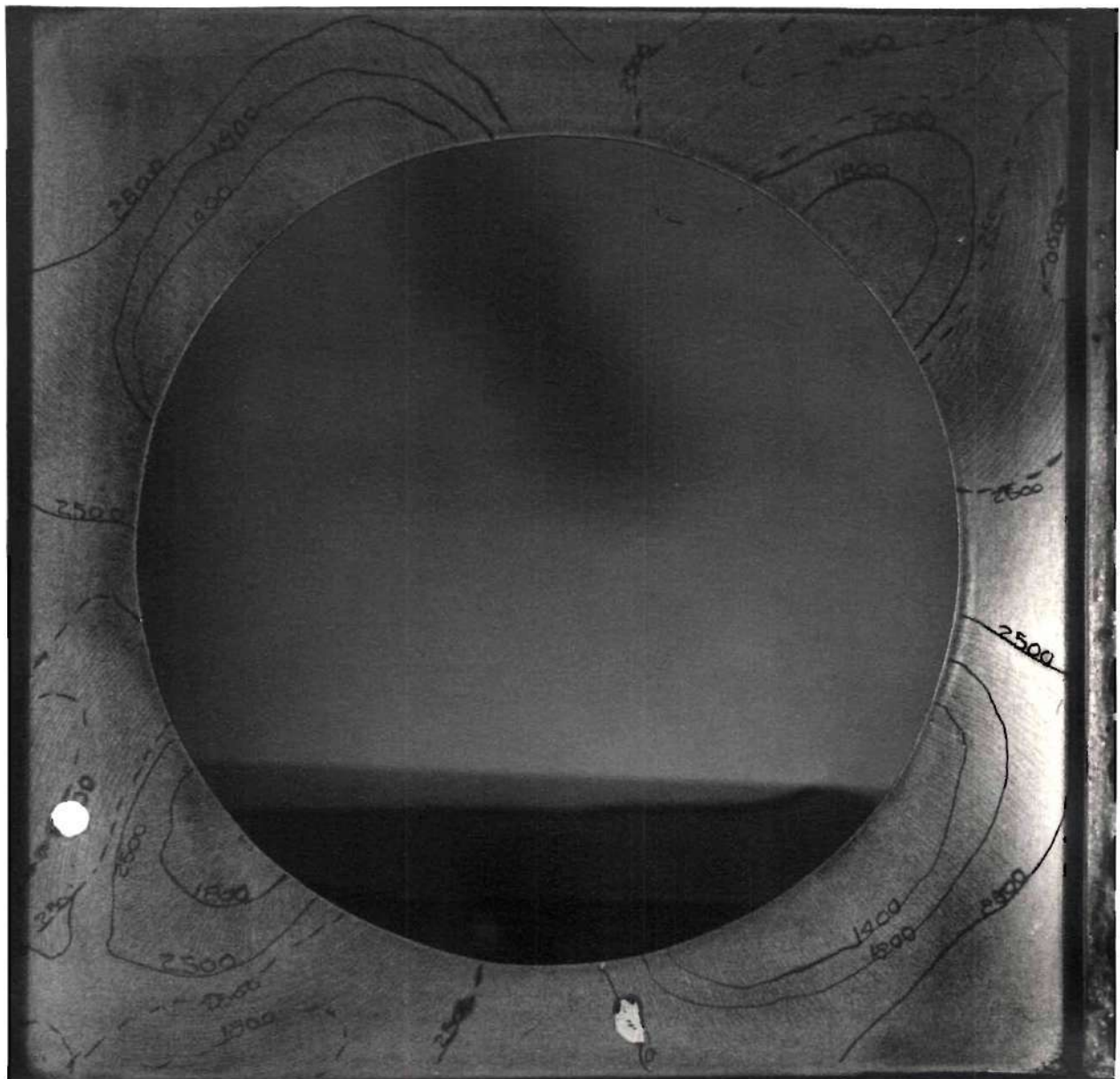


Figure 31. Stress pattern, 0.064 panel, front.
7 in. diameter access hole.
Sensitivity 0.00110 in./in.
Stresscoat No. ST-1208.

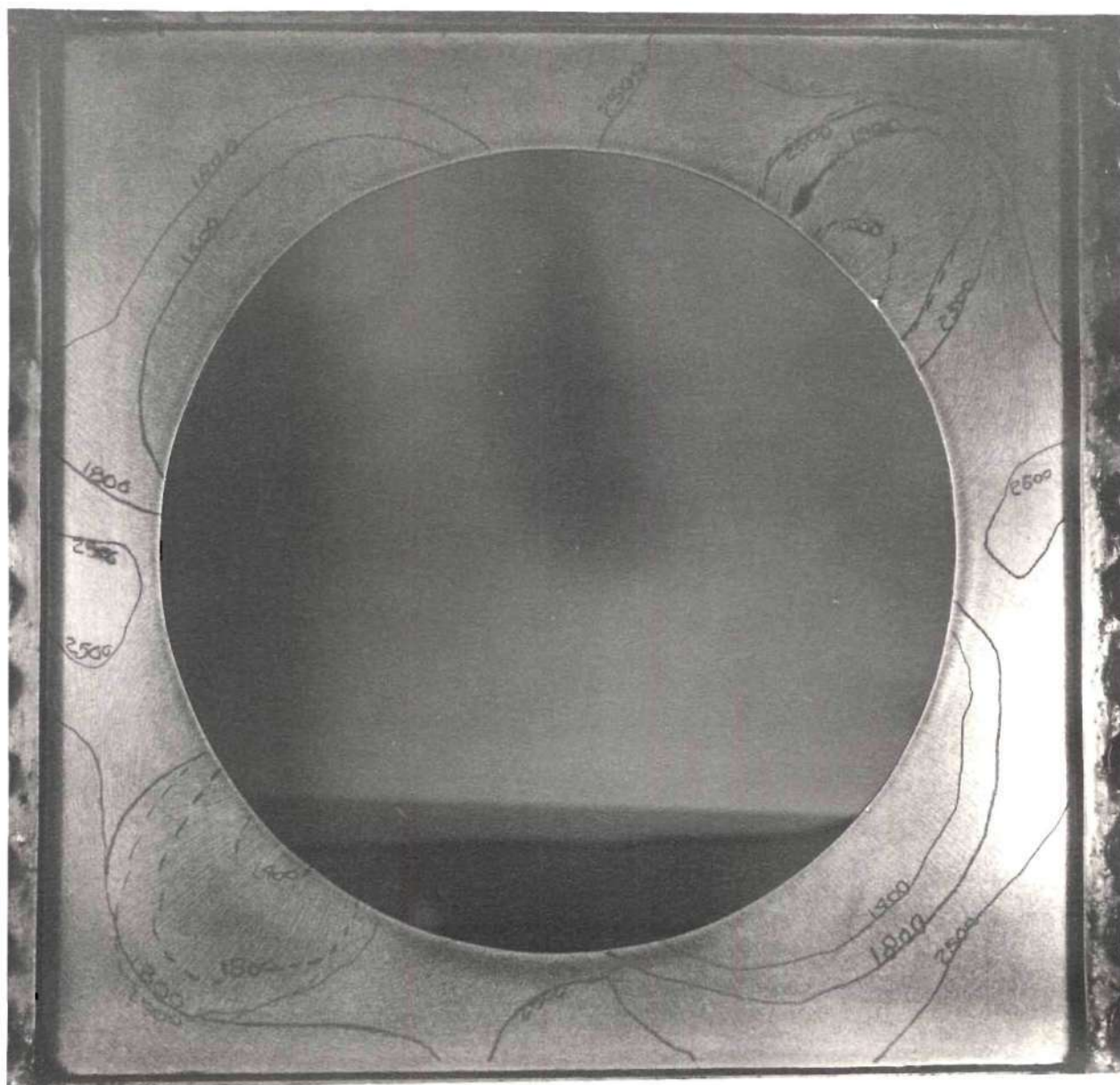


Figure 32. Stress pattern, 0.064 panel, rear.
7 in. diameter access hole.
Sensitivity 0.00110 in./in.
Stresscoat No. ST-1208.

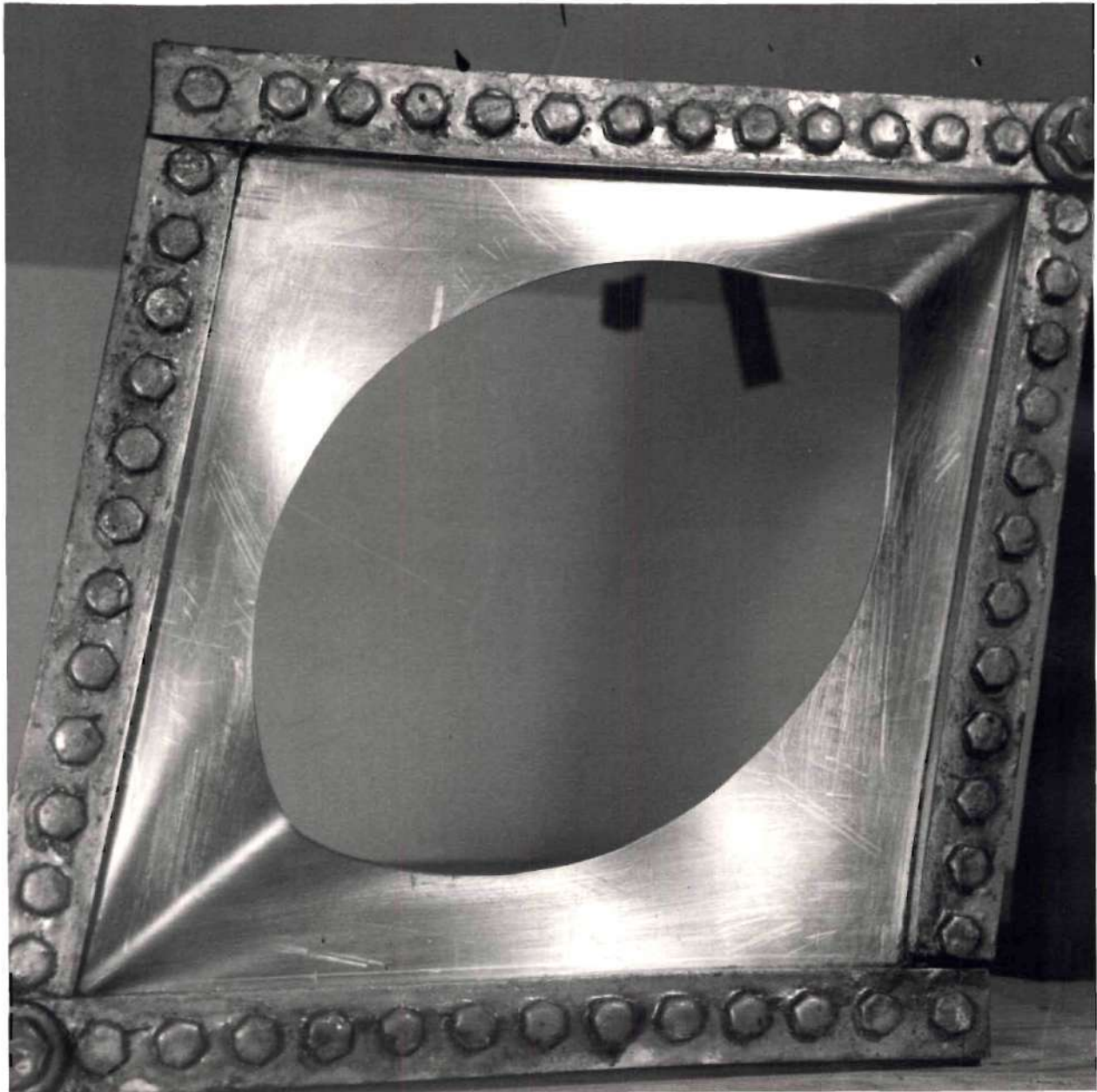


Figure 33. Rupture at lower left hand corner.
7 in. diameter access hole.